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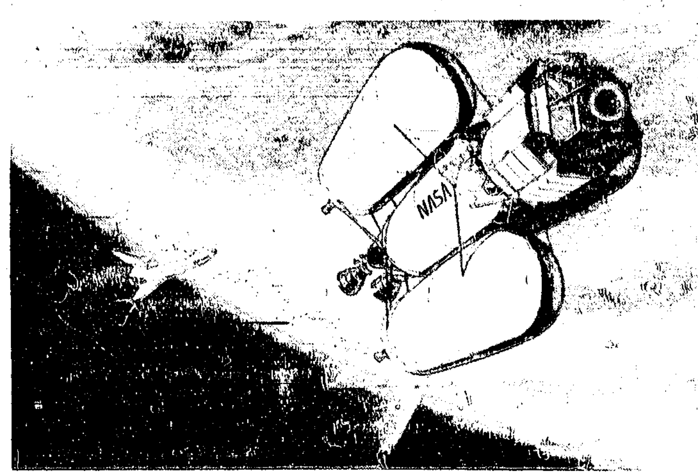
MANNED ORBITAL TRANSFER VEHICLE (MOTV)

volume 2
mission handbook



GRUMMAN AEROSPACE CORPORATION

MANNED ORBITAL TRANSFER VEHICLE (MOTV)

volume 2
mission handbook

prepared for
National Aeronautics and Space Administration
Johnson Space Center
Houston, Texas

prepared by
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Bethpage, New York 11714

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FOREWORD

This final report documents the results of a study performed under NASA Contract NAS 9-15779. The study was conducted under the technical direction of the Contracting Officer's Representative (COR), Herbert G. Patterson, Systems Design, Johnson Space Center. Mr. Lester K. Fero, NASA Headquarters, Office of Space Transportation Systems, Advanced Concepts, was the cognizant representative of that agency.

The Grumman Aerospace Corporation's study manager was Charles J. Goodwin. The major contributors and principal investigators were Ron E. Boyland, Stanley W. Sherman and Henry W. Morfin.

This final report consists of the following volumes:

- Executive Summary - Volume 1
- Mission Handbook - Volume 2
- Program Requirements Document - Volume 3
- Supporting Analysis - Volume 4
- Turnaround Analysis - Volume 5
- Five Year Program Plan - Volume 6

1 - INTRODUCTION

The intent of the Mission Handbook is to define for the reader how the MOTV may be used to support future space missions. Some 20 generic missions have been defined, each one representative of the types of missions expected to be flown in the future. MOTV support of these 20 missions is defined in detail and illustrates the full functional and performance capabilities of the MOTV. The user, by turning to the appropriate generic mission nearest describing the one he has in mind, can thus select the MOTV configuration best supporting that mission. More complex missions involving several flights of an MOTV requiring a mixture of various generic missions can also be constructed from the basic 20 missions described herein. Besides describing the propulsive and functional capabilities required of the MOTV to support a particular mission, the Handbook also contains data to enable the user to determine the number of STS flights needed to support the mission, mission-peculiar equipment requirements, parametrics on mission phasing and ΔV requirements, ground and flight support requirements, recovery considerations, and IVA/EVA trade analysis.

2 - MISSION SELECTION CRITERIA

The objectives of the generic missions are to provide realistic, operationally feasible, but stringent, missions to exercise the MOTV systems to their maximum planned capability wherever possible. These missions form the basis for deriving MOTV functions and performance requirements. With this objective in mind the following guidelines and assumptions apply to the missions described herein.

2.1 POTENTIAL USER PROGRAMS SUMMARY

Figure 2-1 is a summary of potential user programs and appropriate references for each. These programs formed the background in deriving the generic missions described below. Although the generic missions cannot be related to these user programs on a one-to-one basis, they do incorporate the essential characteristics of many of the user programs.

2.2 GROUNDRULES & ASSUMPTIONS

The following groundrules and assumptions were used in developing the material presented in this handbook.

- Mission Phases - Figure 2-2 identifies the mission phases with respect to the overall MOTV mission. The handbook focuses on "OTV Mission Operations" and treats the other phases in a less detailed manner.
- Abort timelines are not part of the handbook nor are contingency operations.
- Within the domain of "OTV Mission Operations" are those functions and tasks concerned with "Vehicle Operation and Control" and those concerned with "Sortie Operations." The timeline developed in this handbook relates primarily to "Sortie Operations (see Fig. 2-3).
- All "Sortie Operations" are conducted IVA whenever possible. EVA is provided for contingency and emergency operations. It is assumed that EVA will be necessary twice per sortie mission except for passenger transport missions P1 to P4 where one EVA per mission is assumed.

PROGRAM	AGENCY	IOC	DESTINATION ALT (N MI)	DESTINATION INCL (DEG)	SAT WEIGHT (kg)	INFORMATION SOURCE COMPANY	INFORMATION SOURCE CONTRACT
150 kW SPDA CR 1	NASA	1984	GEO	0°	23,200	GAC	NAS8-31993
CR 2		1984			25,090		
2 MW SPDA		1988			32,251		
50 MW SPDA		1993			800,000		IN-HOUSE
GEO ENV INTER EXP		1988			6,800		IN-HOUSE
PSP NO. 1		1986			27,451	GAC	NAS8-31993
PSP NO. 2		1991			9,125		
PSP No. 3		1992			27,451		
OUTPOST IN GEO		1991			26,000		
SPACE BASED RADAR	MIL						
60-m ANT.					3,610	GAC	IN-HOUSE
180-m ANT. – INTEG					6,804		
– MOD					4536 + 2313		
– MOD SENSOR					5879 + 3611		
– EXP TRUSS					11215 + 4239		
300-m – INTEG					13,495		
– MOD					10727 + 2767		
– MOD SENSOR					12301 + 5248		
– EXP TRUSS					34259 + 5630		
LUNAR MINING BASE	NASA	1990s	LUNAR	–	–	GAC	IN-HOUSE
LUNAR RADIO QUIET FAC				–	–		
POLAR SYNCH EARTH OBS				–	–		
HALO	MIL	1990	GEO	0°	13,600		IN-HOUSE

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Fig. 2-1 Potential MOTV User Programs November 1978

PROGRAM	AGENCY	IOC	DESTINATION ALT (N MI)	DESTINATION INCL (DEG)	SAT WEIGHT (kg)	INFORMATION SOURCE COMPANY	INFORMATION SOURCE CONTRACT
EARTH OBSER	NASA	1983	SUN SYNCH	OR GEO	700	GAC	NAS8-31993
– EXTRACT. RES							
– CAL FAC		1983	GEO	0	400		
– WEATHER & CLIMATE		1983	GEO	0	1,200		
– INTER SAT COMMUN		1983	GEO	0	176		
SPACE PHYS & ASTRO							
– IR OBS			SUN SYNCH		4,000		
– DEEP SKY SURVEY			(800-	(60-80)	2,200		
– SMALL OPT. OV TEL			1400 km)		2,000		
– ADV XUV TEL					500		
– SUBILLIMETER IR TEC			SUN SYNCH		1,500		
– COMB OV MISSION					4,000		
– LOW ENER X-RAY TEL			200-800	0-10	2,000		
– PIGGY BACK RAD TEL			GEO	0	100		
– LARGE APER TEL			GEO OR SUNSYN		2,000		
– SYN. APER INTER			GEO OR SUNSYN		2,500		
– MAGNETOSPHERE OBS			GEO		4,000		

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Fig. 2-1 Potential MOTV User Programs November 1978 (Contd)

PROGRAM	AGENCY	IOC	DESTINATION ALT (N MI)	DESTINATION INCL (DEG)	SAT WEIGHT (kg)	INFORMATION SOURCE COMPANY	INFORMATION SOURCE CONTRACT
PUBLIC SERVICE	NASA						
– FOREST FIRE DET		1990	GEO	0°	11,340	GAC	NASB-31993
– BORDER SURV		1990			1,542		
– COSTAL PASSIVE RAD		1995			49,895		
– ELECT MAIL		1990			3,856		
– URBAN/POLICE RADIO		1990			3,674		
– DISASTER SAT. CONT		1990			3,674		
– VOTING/POLLING SYS		1990			3,674		
– NAT INFO SERV SYS		1990			3,856		
– ENER GEN PLT (RTG)		2000	1000	–	6.8×10^6		
– PERS COMMUN		1990	GEO	0°	4,173		
– NUCL WASTE DISP		1990	ESCAPE		29,030		
– CITY NIGHT ILLUM		1990	GEO	0°	68,039		
– VEH SPEED CONT		1990	GEO + INCL.		4,536		
– SPACE DEBRIS SWEEPER		1985	UP TO GEO		226,795 (PROP)		
– INEXP NAV SYST		1990	GEO	0°	590		
– SYNCH METEOROLOG SAT.		1985	GEO	0°	1,361		
– EXTREM HIGH RESOL OBS		2000	2500	45°	18,144		
– NUCL FUEL LOC SYS		1985	SYNCH ELLIPT/INCL		907		
– BURG ALARM/INT DET		1990	GEO	0°	11,340		
– 3D HOLOGRAPH TELECON		1995	GEO	0°	6,804		
– ADV TV BROADCAST		1990	GEO	0°	9,072		
– GLOBAL EARTHQUAKE DET		1990	GEO	0°	3,856		
– WATER AVAIL. INDIC		1990	GEO	0°	3,674		
ELECT. MAIL	NASA	1985	GEO	0°	3,629	AEROSPACE	NASW-3141
EDU TV		1985			4,536		
PERSONAL COMMUN		1987			24,539		
DATA ACQUIS PLAT		1987			6,803		
INFOR SERV PLAT		1995			34,019		

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Fig. 2-1 Potential MOTV User Programs November 1978 (Contd)

PROGRAM	AGENCY	IOC	DESTINATION		SAT WEIGHT (kg)	INFORMATION SOURCE	
			ALT (N MI)	INCL (DEG)		COMPANY	CONTRACT
GEO COMMUN PLAT	NASA	1988	GEO	0°	9,072	AEROSPACE	NASW-3141
SOLAR/TERRES OBS		1987	GEO	0°	9,979		
NUCL WASTE DISP		1987	ESCAPE		9,525		
JUPITER BODY PROBE		1990			2,722		
MARS LAND/SAMP RET		1990			28,123		
SAT PWR SYST GEO SAT		1985	GEO	0°	6,804		
COMSAT NO. 1	DOD	1987	GEO	0°	4,536		
COMSAT NO. 2		1988	12 HR	63°	4,536		
COMSAT NO. 3		1990	500,000	–	2,268		
SURVEILLANCE NO. 1		1988	GEO	0°	22,680		
NO. 2		1989	12 HR	63°	22,680		
NO. 3		1986	GEO	0°	11,340		
NO. 4		1987	12 HR	63°	11,340		
NO. 5		1990	GEO	0°	45,359		
NO. 6		1991	12 HR	63°	45,359		
COMMAND POST		1998	500,000	–	45,359		
25 kW PWR MOD	NASA	1987	HEO	–			
250 kW PWR MOD		1939		–			
GEO SPACE CONST FAC		1987	GEO	0°			
100 m DEPL ANT.			GEO	–	1,818	GAC	NAS 8-32344

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Fig. 2-1 Potential MOTV User Programs November 1978 (Contd)

PROGRAM	AGENCY	IOC	DESTINATION ALT (N MI)	DESTINATION INCL (DEG)	SAT WEIGHT (kg)	INFORMATION SOURCE COMPANY	INFORMATION SOURCE CONTRACT
PHINHOLE X-RAY/GRAV	NASA	1987	LI	–	16,783	AEROSPACE	NASW-3141
SJ	DOD	CLASSIFIED			226,755		
DSCP					136,077		
SM-V					22,680		
SM-VI					22,680		
SM-VII					45,359		
SPACE BASED RADAR (257 m x 149 LENS)	–	–	GEO	0°	10,501		
	–	–			19,495		
	–	–			16,152		
DATA ACQUIS. PLAT	NASA	–	900	–	227,000		
60 kW PM	NASA	1987	GEO	0°		[illegible]	NAS 8-32928
GEOSTAT PLATFORM	NASA	1986			8,200		
EDUCATIONAL TV		1988			10,000		
- 50 kW PM		1988			7,000		
PERS EMERG COMSAT		1990			30,000		
- 210 kW PM		1990			10,000		
STO		1990			18,700		
MULTI-DISCIP GEO PLAT		1986			6,500		
- 20 kW		1986			6,500		
- 40 kW		1990			15,000		
50 kW PM	NASA	1988	GEO	0°	2,897	LMSC	NAS 8-32928
25 kW PM NiCD					2,930		
NiH2					2,054		
FUEL CELLS					1,079		
STO		1991	GEO	0°		GAC	NAS 8-31993

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Fig. 2-1 Potential MOTV User Programs November 1978 (Contd)

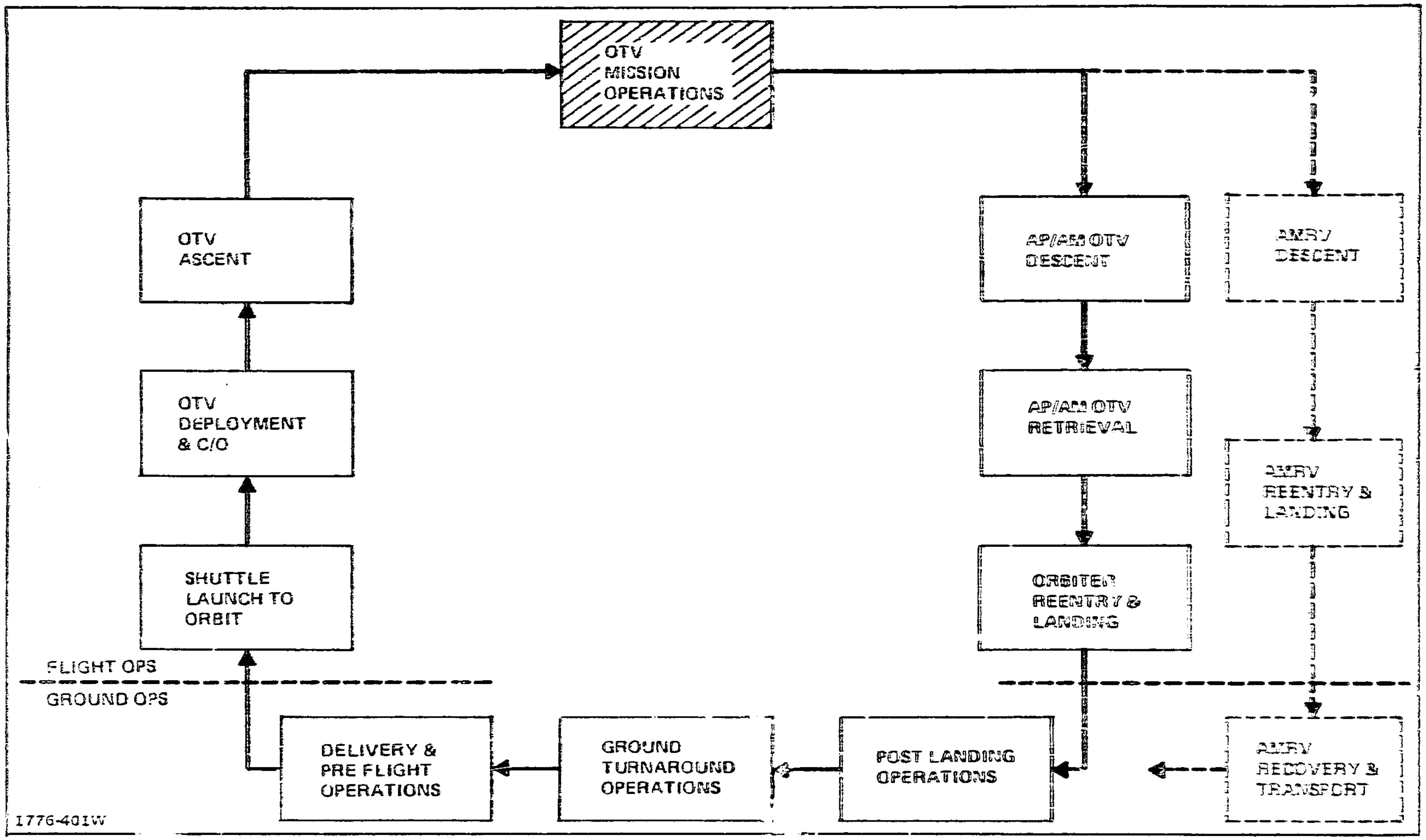

Fig. 2-2 OTV Top Level Mission Phases (A-OTV, AMOTV, & AMRV)

- SHUTTLE LAUNCH TO ORBIT
  - LAUNCH TO ORBIT
  - ORBITER RENDEZVOUS & DOCK/BERTH
- OTV DEPLOYMENT & C/O
  - VEHICLE DEPLOYMENT
  - OTV ORBITAL STORAGE
  - OTV SYSTEM BUILD UP
  - CREW TRANSFER
  - PRE-ASCENT CHECKOUT
- OTV ASCENT
  - PHASING ORBIT INSERTION
  - TRANSFER ORBIT INSERTION
  - MISSION ORBIT INSERTION
  - ORBIT ADJUSTMENT OR RENDEZVOUS & DOCK/BERTH
- OTV MISSION OPERATIONS
  - VEHICLE OPERATION & CONTROL (CONSTRUCTION, INSPECTION, SERVICE, ETC)
  - SORTIE OPERATIONS
- APOTV DESCENT
  - TRANSFER ORBIT INSERTION
  - PHASING ORBIT INSERTION
  - CIRCULARIZATION
- APOTV RETRIEVAL
  - ORBITER RENDEZVOUS & DOCK/BERTH
  - CREW TRANSFER
  - PAYLOAD TRANSFER
  - OTV SYSTEM REMOVAL
  - VEHICLE RETRIEVAL
- ORBITER REENTRY & LANDING
  - DEORBIT & REENTRY
  - LANDING

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Fig. 2-3 OTV Flight Operation Phases

- The APOTV is baselined for all MOTV operations
- The maximum warning time due to solar storms is 12 hr. No storm shelter is provided for GEO or HEO missions, therefore, abort within their 12 hr warning period is imperative. For the Deep Space mission, P4, a shelter is provided due to the long journey time, 14 days, to orbit.
- Mission Timeline Groundrules are as shown in Fig. 2-4.
- Typical work/rest cycles for transit periods between earth and GEO and return are shown in Figs. 2-5 and 2-6.

• NOMINAL CHECKOUT (ASSUMING REMOTE MANIPULATOR COMPLEXITY)		~ 5 MIN
• TYPICAL SUBSYS MODULE INSTALLATIOI INCLUDES		~ 50 MIN
– UNSTOW, TRANSLATE & ATTACH MOUNTING PAD,	~ 5 MIN	
– UNSTOW, TRANSLATE 20m, POSITION & ALIGN MODULE	~ 5 MIN	
– ADJUST & FASTEN MODULE MECHANICAL ATTACHMENTS	~ 5 MIN	
– ATTACH ELECTRICAL CONNECTORS (POWER & DATA READOUT)	5 MIN	
– NOMINAL CHECK/OUT	5 MIN	
	25 MIN	
– PLUS ADDED TIME FOR INSPECTION & SET UP SAY	25 MIN	
OR	50 IN	
• DEPLOY ANTENNAS		1 MIN/METER RADII
• OPERATE BEAM MACHINE		1 MIN/METER
• DEPLOY STEM DEVICES		1 MIN/3 METERS
• TYPICAL NESTED TUBE (i.e., DIXIE CUP) CONSTRUCTION INCLUDES		10 MIN EACH
– UNNEST, TRANSLATE & JOIN DIXIE CUP STRUTS (AUTOMATE)	~ 2 MIN	
– TRANSLATE 20 m & ALIGN	3 MIN	
– ADJUST & FASTEN TO FITTINGS (BOTH ENDS)	5 MIN	
	10 MIN	
• DEPLOY SOLAR ARRAY		10 MIN

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Fig. 2-4 MOTV Mission Timeline Groundrules

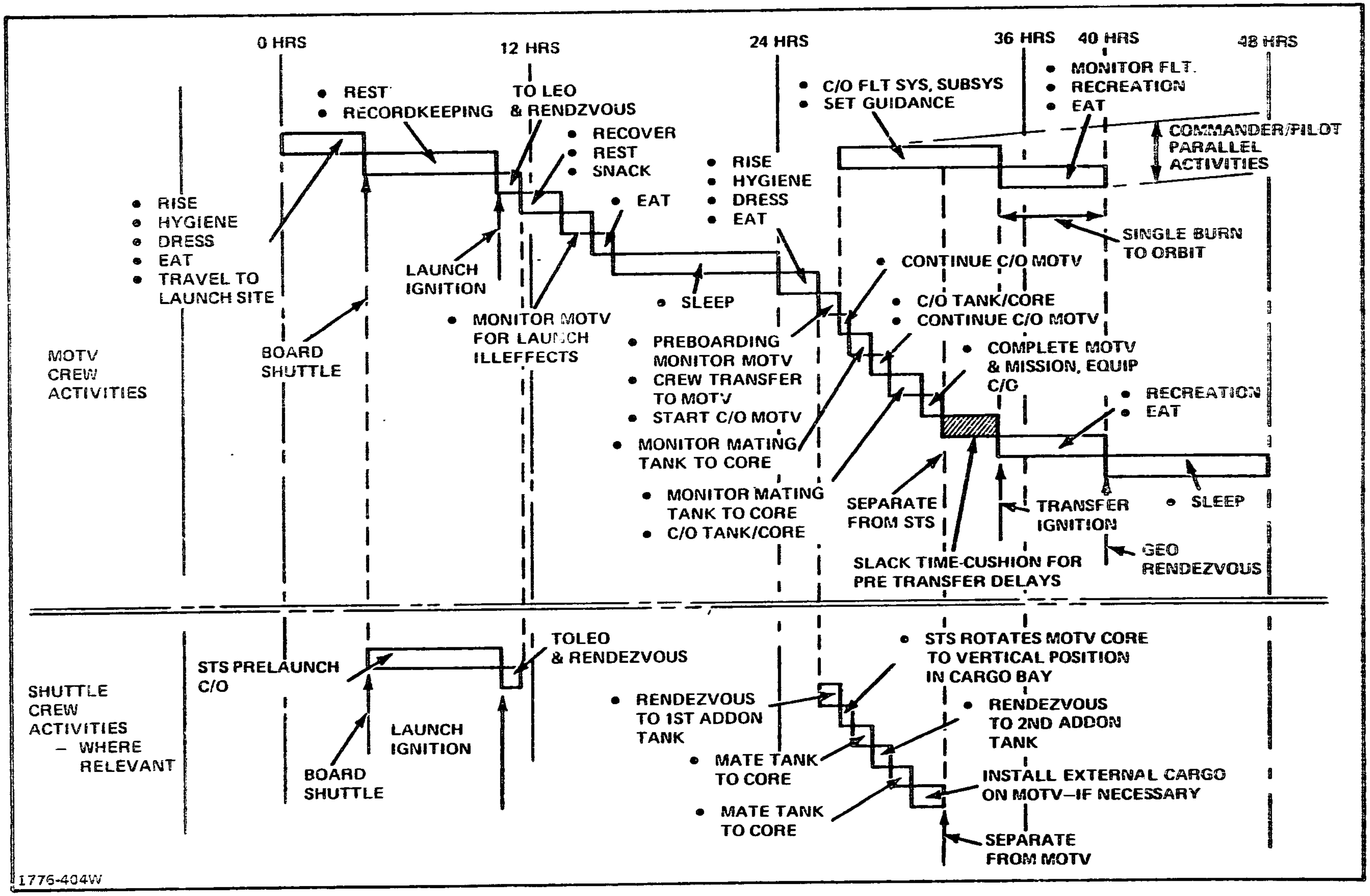

Fig. 2-5 Earth to GEO Timeline

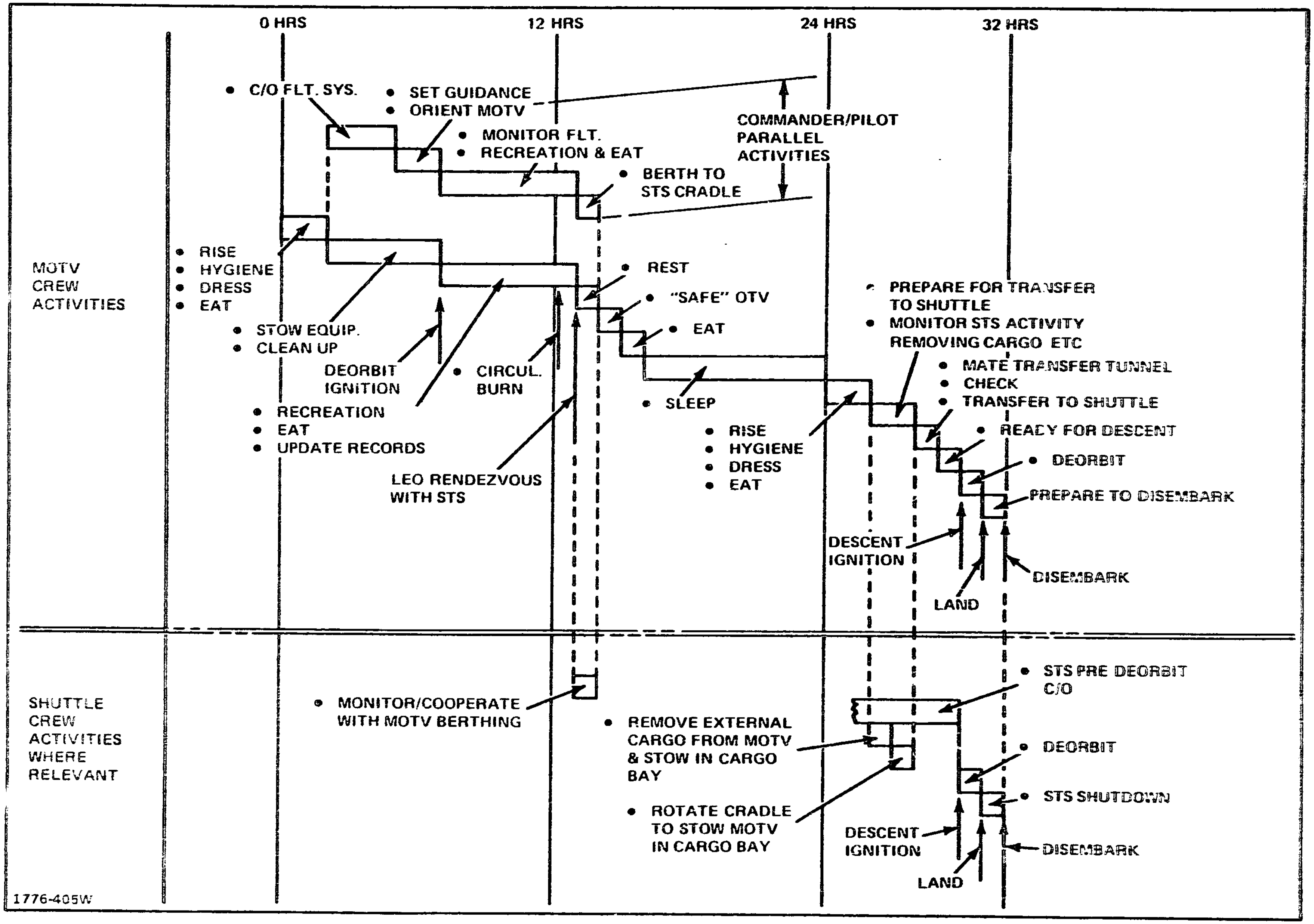

Fig. 2-6 GEO to Earth Timeline

3 - Generic Mission Summary

The following is a summary of 20 generic mission scenarios; seven have been selected for detailed study & illustration.

From the data presented here specifics for more complex missions may be drawn from the seven generic missions which cover a variety of categories & non-orbit functions. Thus, nearly any mission desired may be compiled from both the basic missions presented here plus the mission parameters. The proper MOTV configuration can then be selected. Figures 3-1 through 3-8 summarize the salient features and performance characteristics of all generic missions.

GENERIC MISSION		SCENARIO CHARACTERISTICS				
CATEGORY	SYMBOL	ORBIT	MISSION HDWR (kg)	CREW	DURATION (DAYS)	DESCRIPTION
INSPECTION SERVICE & REPAIR	IN1	GEO	510	2	4	SCIENTIFIC SATELLITE REVISIT
	$\boxed{S1}$	GEO	1684	3	19	MODULAR LEVEL SERVICE
	S2	GEO	2966	3	27	COMPONENT LEVEL SERVICE & UPDATE
	S3(a)	GEO	2600	2	21	SERV & UPDATE NUCL PWRD SATS
	(b)	GEO	2000	2	3	REPLACE NUCL REACTOR
	ER1	GEO	453	2	4	EMERGENCY REPAIR (GEO)
	$\boxed{ER2}$	12 HR/63	272	2	4	EMERGENCY REPAIR (HEO)
	R1	12 HR/63	4100	3	2	FAILED SATELLITE
OPERATION OF A LARGE SPACE SYSTEM	OP1	GEO	650	2	16	TENDED STO
	P1	GEO	1683	2	4	3 MAN CREW ROTATION/RESUPPLY
	$\boxed{P2}$	GEO	4485	2	4	10 MAN CREW ROTATION/RESUPPLY
	P3	GEO	16,819	2	4	30 MAN CREW ROTATION/RESUPPLY
	$\boxed{P4}$	DEEP SPACE	3364	2	30	6 MAN CREW ROTATION/RESUPPLY
DEBRIS REMOVAL	$\boxed{DR1}$	GEO	6500	2	9	REMOVE DEBRIS FROM A 45° SECTOR OF GEO
CONSTRUCTION	C1	GEO	10,000	2	3	UNFOLD WIRE WHEEL ANTENNA
	C2		16,000	3	6	UNFOLD COMMUN PLATFORM
	$\boxed{C3}$		17,000	3	6	PREFAB COMMUN PLATFORM
	C4		15,000	3	7	AUTOFAB COMMUN PLATFORM
	C5		110,535	3	14/5/5/5	AUTOFAB SPDA
	$\boxed{C6}$		–	2	17	MODULAR ASSY SPDA
UNMANNED CARGO	UC	VARIOUS	15,000 55,000	NONE		SECONDARY ROLE

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SYMBOLS
- IN = INSPECTION
- S = SERVICE
- ER = EMERG REPAIR
- R = RETRIEVAL
- OP = OPER. LG SPACE SYSTEM
- P = PASS. TRANSPORT
- DR = DEBRIS REMOVAL
- C = CONST
- UC = UNMAN. CARGO

$\boxed{}$ SELECTED FOR DETAILED STUDY

Fig. 3-1 Generic Missions

MISSION	DURATION DAYS	NOMINAL REQ-KWHR	RESERVE KWHR	TOTAL	MISSION	DURATION DAYS	NOMINAL REQ-KWHR	RESERVE KWHR	TOTAL
IN1	3.8	230	143	373	DR1	8.3	544	143	687
S1	19	1131	143	1274	C1	3	157	143	300
S2	27	1637	143	1780	C2	5.6	347	143	490
S(o)	21				C3	6.0	376	143	519
(h)	3								
ER1	3.6	208	143	351	C4	6.8	435	143	578
ER2	3.4	230	143	373	C5	5	427	143	570
R1	2.5	138	143	281		14	938	143	1081
OP1	16	1106	143	1249	C6	26	1836	143	1980
P1	4	230	143	373	UC	TBD			
P2	4	264	192	456					
P3	4	316	336	652					
P4	30	2796	173	2969					

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Fig. 3-2 Mission Energy Requirements

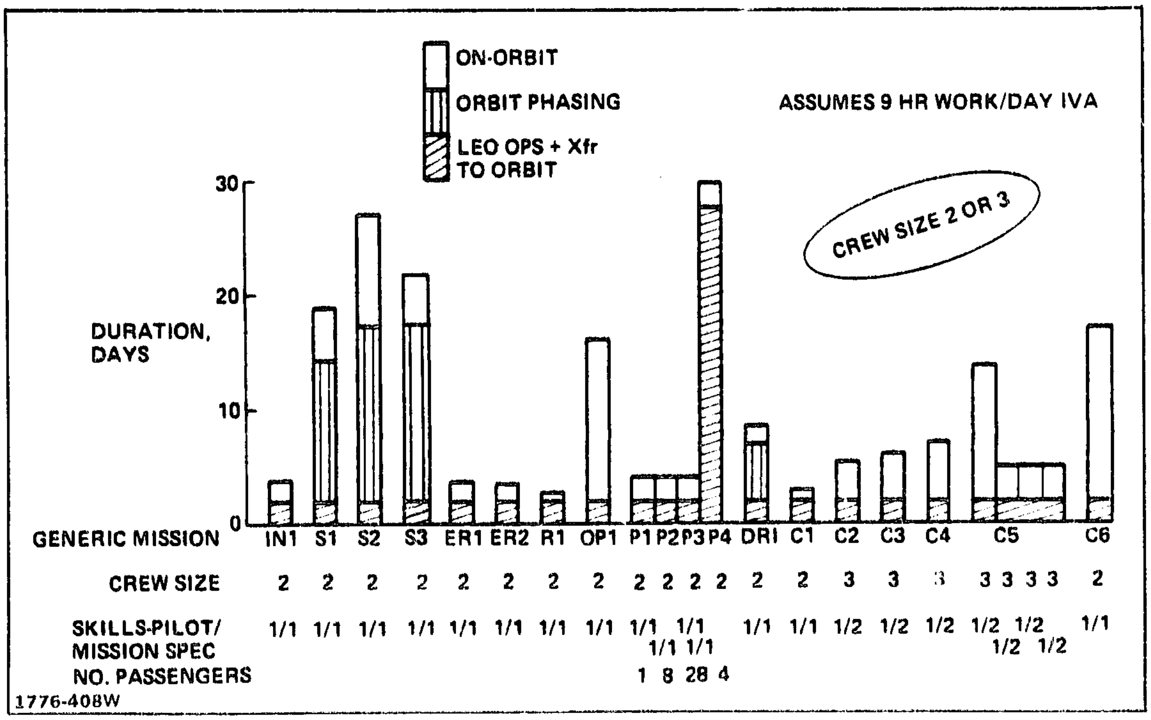

Fig. 3-3 Generic Mission Duration, Crew Size, & Skill Requirements

		ASCENT TO ORBIT	DESCENT FROM ORBIT	ON-ORBIT TIME*	TOTAL MOTV DURATION	NO. CREW
INSPECTION SERVICE & REPAIR	IN1	0.75	1.2	1.8	3.8	2
	S1	0.75	1.2	16.8	18.8	2
	S2	0.75	1.2	24.9	26.9	2
	S3(a)	0.75	1.2	18.6	20.6	2
	(b)	0.75	1.2	2.5	4.4	2
	ER1	0.75	1.2	1.7	3.6	2
	ER2	0.75	1.2	1.4	3.4	2
	R1	0.75	1.2	0.5	2.5	2
OPERATION OF A LARGE SPACE SYSTEM	OP1	0.75	1.2	14.0	16.0	2
	P1	0.75	1.2	2.0	4.0	3
	P2	0.75	1.2	2.0	4.0	10
	P3	0.75	1.2	2.0	4.0	30
	P4	13.6	14.0	2.0	29.6	6
DEBRIS REMOVAL	DR1	0.75	1.2	6.3	8.3	2
CONSTRUCTION	C1	0.75	1.2	0.9	2.9	2
	C2	0.75	1.2	3.6	5.6	3
	C3	0.75	1.2	4.0	6.0	3
	C4	0.75	1.2	4.8	6.8	3
	C5	0.75 x 4	1.2 x 4	11.7 x 2.7 x 3	13.7/4.7/ 4.7/4.7	3
	C6	0.75	1.2	14.7	16.7	2
UNMANNED CARGO	UC	•				0

*ASSUMES 9 HR WORK PER DAY IVA

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Fig. 3-4 Mission Duration Days

	INSPECTION, SERVICE & REPAIR						
EQUIPMENT	IN1	S1	S2	S3(a)	S3(b)	ER1	ER2
• MANIPULATORS							
- REACH (m)	2.5	2.0	2.5	2.5	2.5	2.5	3.0
- DOF	7	7	7	7	7	7	7
- NO. REQD.	2	2	2	2	2	2	3
- UNIT WGT (kg)	195	178	185	195	195	185	210
• STABILIZER FOR BERTHING							
- REACH (m)	2	2	2	2	2	2	2
- DOF	4	4	4	4	4	4	4
- NO. REQD.	1	1	1	1	1	1	1
- UNIT WGT (kg)	50	50	50	50	50	50	50
• EVA SUITS							
- TYPE/NO. REQD.	GEO/2	GEO/2	GEO/2	GEO/2	GEO/2	GEO/2	GEO/2
- NO. EVA'S PERMISSION (NORM OR EMERG)	2 (EMERG)	2 (EMERG)	2 (EMERG)	2(EMERG)	2 (EMERG)	1 (EMERG)	1 (EMERG)
- ENDURANCE TIME/EVA (HR)	6	6	6	6	6	6	6
- RAD PROTECTION REQD.	NO	NO	NO	YES	YES	NO	NO
- TETHER	YES	YES	YES	YES	YES	YES	YES
- UNIT WGT (kg)	137.5	137.5	137.5	137.5	137.5	137.5	137.5
• MMU'S							
- NO. REQD.	-	--	--			--	--
- MAX. RANGE/EVA (m)		-	—			-	
- UNIT WGT (kg)		-				-	-
• DOCKING							
- TYPE						--	-
- NO. REQD.		--				-	
- UNIT WGT (kg)		-	-				
• C/O & CALIB EQUIP.							
- TYPE OF C/O REQD.	SUBSYST C/O	MMS + ANT. FEED C/O	COMP. + ANT. FEED C/O	COMP. + ANT FEED C/O	--	ANT. FEED + COMP. C/O	SURV SAT. SUBSYST C/O
CRYO FLUID REPLENISHMENT	-	-	-		—	-	-
WGT ALLOCATION (kg)	10	10	10	30	—	10	10
• EQUIP. STOWAGE RACKS, CONTAINERS							
- TYPE	EXP TRAY RACK	MMS HOLDERS	TWT HOLDERS	BLACK BOX RACKS	—	ANT.+EQUIP. HOLD.	SENSOR MOD + S/A + RCS
NO. REQD.	1	12	40		—	2 HOLDERS	2 HOLDERS
SIZE (m)	1 x 1	1.2x1.2x0.46	0.4x0.6x0.9			30 m ANT.+COMP	VARIOUS
UNIT WGT (kg)	20	8	3	200	—	20	20

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FOLDOUT FRAME

		OPER OF A LG SPACE SYST		DEBRIS REMOVAL	CONSTRUCTIO		
ER2	R1	OP1	P1-P4	DR1	C1	C2	C3
3.0 7 3 210	2.5 7 2 195	2.5 7 2 195		4.0 7 2 237	4 7 1 237	4 7 2 237	4 7 2 23
2 4 1 50	2 4 1 50			2 4 1 50			2 4 1 50
GEO/2 1 (EMERG) 6 NO YES 137.5	GEO/2 1 (EMERG) 6 NO YES 137.5	GEO/2 2 (EMERG) 6 NO YES 137.5	1 LEO+1 IN-CABIN/CREWMEN 6 NO NO 137.5	GEO/2 1 (EMERG) 6 NO YES 137.5	GEO/2 2 (EMERG) 6 NO YES 137.5	GEO/3 2 (EMERG) 6 NO YES 137.5	GEO/3 2 (EMERG 6 NO YE 13
— — —	2 100 135	— — —	— — —		2 100 135		2 10 13
— — —	- - -	INT'L DOCK 1 408	INT'L DOCK 1 408	— — —	— — —	— — —	— — —
SURV SAT. SUBSYST C/O - 10	SAFING & C/O - 10	SUBSYST + INSTR C/O 5 kg CH2+5 kg CH4 10 + 10 = 20	- - - -	SAFING & C/O - 10	ANT.FEED + ANT.PATTERN C/O - 10	SUBSYST + ANT. FEED C/O - 10	SUBSYST ANT.FEE - 10
SENSOR MOD + S/A + RCS 2 HOLDERS VARIOUS 20	P/L RET. LATCHES 4 LATCHES - 20	SAMP TRAY + RCS + SUBSYS LATCHES + BRACKETS VARIOUS 40	RESUPPLIES 49 LATCHES 16 BOXES (3 EA) 5	STOW.RACK 1 3 m TRIANGLE 100		17 ANT.PACKAGES + 2 S/A + SS 60 LATCHES VARIOUS 5	SAME AS C2 VARIOUS 5

	DEBRIS REMOVAL	CONSTRUCTION						UNMANNED CARGO
P1-P4	DR1	C1	C2	C3	C4	C5	C6	UC
	4.0 7 2 237	4 7 1 237	4 7 2 237	4 7 2 237	4 7 2 237	4 7 2 237	25 7 2 502	
—	2 4 1 50	—	—	2 4 1 50	—	2 4 1 50		
+1 IN- W/CREWMEN 6 NO NO 137.5	GEO/2 1 (EMERG) 6 NO YES 137.5	GEO/2 2 (EMERG) 6 NO YES 137.5	GEO/3 2 (EMERG) 6 NO YES 137.5	GEO/3 2 (EMERG) 6 NO YES 137.5	GEO/3 2 (EMERG) 6 NO YES 137.5	GEO/3 2 (EMERG) 6 NO YES 137.5	GEO/2 2 (EMERG) 6 NO YES 137.5	
—	—	2 100 135	—	2 100 135	2 100 135	2 100 135	—	—
DOCK 1 408	—	—	—	—	—	—	—	—
	SAFING & C/O - 10	ANT.FEED + ANT.PATTERN C/O - 10	SUBSYST + ANT. FEED C/O - 10	SUBSYST + ANT.FEED C/O - 10	SUBSYST + ANT.FEED C/O - 1C	SUBSYST C/O - 10	SUBSYST C/O - 10	—
PPLIES TCHES XES (3 EA) 5	STOW.RACK 1 3 m TRIANGLE 100	—	17 ANT.PACKAGES + 2 S/A + SS 60 LATCHES VARIOUS 5	SAME AS C2 VARIOUS 5	SAME AS C2 VARIOUS 5	TBD		

Fig. 3-5 Generic Missions Equipment Requirements

FOLDOUT FRAME 3

EQUIPMENT	INSPECTION, SERVICE & REPAIR IN1	S1	S2	S3(a)	S3(b)	ER1	ER2
• FIXTURES/JIGS - TYPES - WGT (kg)							
• BEAM BUILDERS - NO. REQD. - BEAM SIZE (m) - UNIT WGT (kg)							
• EVA TOOLS - TYPES - EST TOTAL WGT (kg)	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25
• SPEC. DIAGNOSTIC EQUIP. - TYPE - EST WGT (kg)	—		— —	PART. DET 10	PART. DET 10	ELECT. ANALYZER 20	ELECT. & REMOT SCANNERS 30
• AIRLOCK - TYPE - UNIT WGT (kg)	—		— —	— —	— —	— —	
• TELEOPERATORS/PROP STAB.UNITS (PSU) - CONTROL STATION LOCATION/NO.REQD. - MAX RANGE (m) - EST UNIT WGT (kg)	— — —		— — —	— — —	TELEOPER. MOTV/1 1000 1100/1481	— — —	PSU MOTV/1 1000 612
• CHERRY PICKER -OPEN/CLOSED - NO.MANIP. ARMS/REACH (m) -NO. GRAPPLERS/REACH (m) - EST WGT (kg)	— —	— — — —	— — — —	— — — —	— — — —	— — — —	— — —
• STORM SHELTER - NO. OCCUPANTS - WGT (kg)				— —	— —		
• OTHER				—	—		

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FOLDOUT FRAME

			OPER OF A LG SPACE SYST		DEBRIS REMOVAL			CONSTRUCTION
	CR2	R1	OP1	P1-P4	DR1	C1	C2	C3
						3m D/A TURNTBL 50	DEPL MAST & GRAPPLER 20	ASSY JIG + STR CONT 50
	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25
YZER	ELECT. & REMOTE SCANNERS 30	REMOTE SCANNERS 30	ELECT. ANALYZER 20					
	PSU MOTV/1 1000 612	PSU MOTV/1 1000 612						

FOLDOUT FRAME 2

	DEBRIS REMOVAL	CONSTRUCTION						UNMANNED CARGO
-P4	DR1	C1	C2	C3	C4	C5	C6	UC
		3m D/A TURNTBL 50	DEPL. MAST & GRAPPLER 30	ASSY JIG + STR CONT 50	FAB/ASSY JIG 100	CORNER ASSY JIG + BEAM SP 100		
					1 1 7500	1 1 7500		
LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	TOOL LIST 25	

FOLDOUT FRAME 3

Fig. 3-5 Generic Mission Equipment Requirements (Contd)

ITEM	INSPECTION, SERVICE & REPAIR												
	INSPECTION IN1		SERVICE S1		SERVICE S2		SERVICE S3(a)		SERVICE S3(b)		EMERG REPAIR ER1		EM
	DE-PLOY	RE-TURN	DE-PLOY	RE-TURN	DE-PLOY	RE-TURN	DE-PLOY	RE-TURN	DE-PLOY	RE-TURN	DE-PLOY	RE-TURN	DE-PLO
• MISSION HDWR													
– REPLACEMENT MODULES, COMPONENTS, SPARES, ETC.	460	460	1084	1084	1600	1600	2000	2000	2000 (NUCLEAR CORE)		403	350	22
– SATELLITE	–	–	–	–						–			
– SAT. SERVICING, RCS, ETC.	60	10	–	–	1406	234	400	100		–	50	8	8
• ON-ORBIT MISSION EQUIP.													
– MANIPULATORS	390	390	366	366	390	390	390	390	390	390	390	390	42
– STABILIZER FOR BERTHING	60	60	50	60	60	50	50	50	60	60	50	50	6
– EVA & IN-CABIN SUITS	276	275	283	283	283	283	276	276	276	276	276	276	27
– MMUs	–	–	–	–	–	–	–	–	–	–	–	–	–
– DOCKING ADAPTER	–	–	–	–	–	–	–	–	–	–	–	–	–
– C/O & CALIB EQUIP.	10	10	10	10	10	10	30	30	10	10	10	10	1
– EQUIP. STOW. RACKS, CONTAIN.	20	20	96	96	120	120	200	200	120	120	40	40	4
– FIXTURES & JIGS	–	–	–	–	–	–	–	–	–	–	–	–	–
– BEAM BUILDERS	–	–	–	–	–	–	–	–	–	–	–	–	–
– EVA TOOLS	25	25	25	26	26	25	26	25	25	25	25	25	2
– SPEC DIAG EQUIP.	–	–	–	–	–	–	10	10	10	10	20	20	3
– AIR LOCK	–	–	–	–	–	–	–	–	–	–	–	–	–
– TELEOPER./PROP. STAB. UNITS	–	–	–	–	–	–	–	–	2581	800	–	–	6
– CHERRY PICKER	–	–	–	–	–	–	–	–	–	–	–	–	–
– STROM SHELTER	–	–	–	–	–	–	–	–	–	–	–	–	–
– OTHER													
• CREW MODULE	2929	2829	3466	3466	3636	3636	3187	3187	2807	2807	2829	2829	28
• CONTINGENCY **	832	832	924	924	959	959	937	937	1502	1057	842	842	10
TOTAL	4941	4891	6883	6883	8438	7268	7604	7204	9770	5544	4934	4839	55

FOLDOUT FRAME 1

INSPECTION, SERVICE & REPAIR												OPER. OF A LARGE SPACE SYSTEM			
SERVICE S2		SERVICE S3(a)		SERVICE S3(b)		EMERG REPAIR ER1		EMERG REPAIR ER2		RETRIEVAL R1		OPER LG SPACE SYS OP1		PASSENG TRANS P1	
DE-PLOY	RE-TURN	DE-PLOY	RE-TURN	DE-PLOY	RE-TURN	DE-PLOY	RE-TURN	DE-PLOY	RE-TURN	DE-PLOY	RE-TURN	DE-PLOY	RE-TURN	DE-PLOY	RE-TURN
1560	1560	2000	2000	2000 (NU-CLEAR CORE)	—	403	350	222	187	—	—	500	500	1433	435
					—					—	4100	—	—		
1406	234	400	100		—	50	8	50	8	—	—	50	8	250	42
390	390	390	390	390	390	390	390	420	420	390	390	390	390	—	—
50	50	50	50	50	50	50	50	50	50	50	50	—	—	—	—
283	283	275	275	275	275	275	275	275	275	275	275	283	283	283	283
—	—	—	—	—	—	—	—	—	—	270	270	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	408	408	408	408
10	10	30	30	10	10	10	10	10	10	10	10	10	10	—	—
120	120	200	200	120	120	40	40	40	40	80	80	40	40	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
—	—	10	10	10	10	20	20	30	30	30	30	20	20	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	2581	800	—	—	612	612	100	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3635	3635	3187	3187	2807	2807	2829	2829	2829	2829	2807	2807	3388	3388	2917	2917
959	959	937	937	1502	1057	842	842	1007	1007	945	920	1006	1006	810	810
8438	7266	7504	7204	9770	5644	4934	4839	5570	5493	4982	8957	6120	6078	6126	4920

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FOLDOUT FRAME 2

Fig. 3-6 Generic Mission Weights (Kg)

ITEM	OPERATION OF A LARGE SPACE SYSTEM						DEBRIS REMOVAL					
	PASSENG TRANS P2		PASSENG TRANS P3		PASSENG TRANS P4		DRI		CONSTRUCTION C1		CONSTRU C2	
	DEPLOY	RETURN	DEPLOY	RETURN	DEPLOY	RETURN	DEPLOY	RETURN	DEPLOY	RETURN	DEPLOY	R
• MISSION HDWR												
– REPLACEMENT MODULES COMPONENTS, SPARES, ETC	3818	1351	14319	5064	2864	867			–	–	–	
– SATELLITE	–	–	–	–	–	–	(5500)***	–	10000	–	16000	
– SAT. SERVICING, RCS, ETC	667	112	2500	420	500	83			–	–	–	
• ON-ORBIT MISSION EQUIP.												
– MANIPULATORS	–	–	–	–	–	–	474	474	237	237	474	
– STABILIZER FOR BERTHING	–	–	–	–	–	–	50	50	–	–	–	
– EVA & IN-CABIN SUITS	321	321	491	491	306	306	275	275	275	275	283	
– MMUs	–	–	–	–	–	–	–	–	270	270	–	
– DOCKING ADAPTER	408	408	408	408	408	408	–	–	–	–	–	
– C/O & CALIB EQUIP.	–	–	–	–	–	–	10	10	10	10	10	
– EQUIP. STOW. RACKS, CONTAIN.	–	–	–	–	–	–	100	100	–	–	300	
– FIXTURES & JIGS	–	–	–	–	–	–	–	–	50	50	20	
– BEAM BUILDERS	–	–	–	–	–	–	–	–	–	–	–	
– EVA TOOLS	25	25	25	25	25	25	25	25	25	25	25	
– SPEC DIAG EQUIP.	–	–	–	–	–	–	–	–	–	–	–	
– AIR LOCK	–	–	–	–	–	–	–	–	–	–	–	
– TELEOPER/PROP. STAB. UNITS	–	–	–	–	–	–	–	–	–	–	–	
– CHERRY PICKER	–	–	–	–	–	–	–	–	–	–	–	
– STORM SHELTER	–	–	–	–	1369	1369	–	–	–	–	–	
– OTHER												
• CREW MODULE	3861	3861	8307	8307	4866	4866	2980	2980	2807	2807	3163	
• CONTINGENCY **	906	906	1404	1404	1402	1402	902	902	854	854	966	
TOTAL	10006	6984	27454	16119	11740	9326	4816	4816	14528	4528	21241	

*1ST C5 FLT; REMAINING 3 FLTS HAVE 28,898 kg DEPLOYED

**25% OF ON-ORBIT MISSION EQUIP. PLUS CREW MODULE LESS CREW AND CONSUMABLES

***PAYLOAD BROUGHT FROM GEO TO GEO + 2000 N MI

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FOLDOUT FRAME 1

DEBRIS REMOVAL DRI		CONSTRUCTION C1		CONSTRUCTION C2		CONSTRUCTION C3		CONSTRUCTION C4		CONSTRUCTION C5		CONSTRUCTION C6		UNMANNED CARGO UC	
…OY	RETURN	DEPLOY	RETURN	DEPLOY	RETURN	DEPLOY	RETURN	DEPLOY	RETURN	DEPLOY	RETURN	DEPLOY	RETURN	DEPLOY	RETURN
		–	–	–	–	–	–	–	–	40	–	–	–		
***	–	10000	–	16000	–	17000	–	15000	–	(23841)*	–	–	–		
		–	–	–	–	–	–	–	–	–	–	–	–		
	474	237	237	474	474	474	474	474	474	474	474	390	390		
	50	–	–	–	–	50	50	–	–	–	–	50	50		
	275	275	275	283	283	283	283	283	283	283	283	275	275		
	–	270	270	–	–	270	270	270	270	270	270	–	–		
	–	–	–	–	–	–	–	–	–	408	408	–	–		
	10	10	10	10	10	10	10	10	10	10	10	10	10		
	100	–	–	300	300	300	300	300	300	20	20	–	–		
	–	50	50	20	20	50	50	100	100	100	–	–	–		
	–	–	–	–	–	–	–	–	–	7500	–	–	–		
	25	25	25	25	25	25	25	25	25	25	–	25	25		
	–	–	–	–	–	–	–	–	–	–	–	–	–		
	–	–	–	–	–	–	–	–	–	–	–	–	–		
	–	–	–	–	–	–	–	–	–	–	–	–	–		
	–	–	–	–	–	–	–	–	–	–	–	–	–		
	–	–	–	–	–	–	–	–	–	–	–	–	–		
	2980	2807	2807	3163	3163	3163	3163	3186	3186	3343	3343	3119	3119	5000	2000
	902	854	854	966	966	1054	1054	1057	1057	1105	1105	872	872	TO	TO
	4816	14528	4528	21241	5241	22679	5679	20705	5705	37419	5913	4741	4741	50,000	20,000

FOLDOUT FRAME 2

Fig. 3-6 Generic Mission Weights (kg) (Cont)

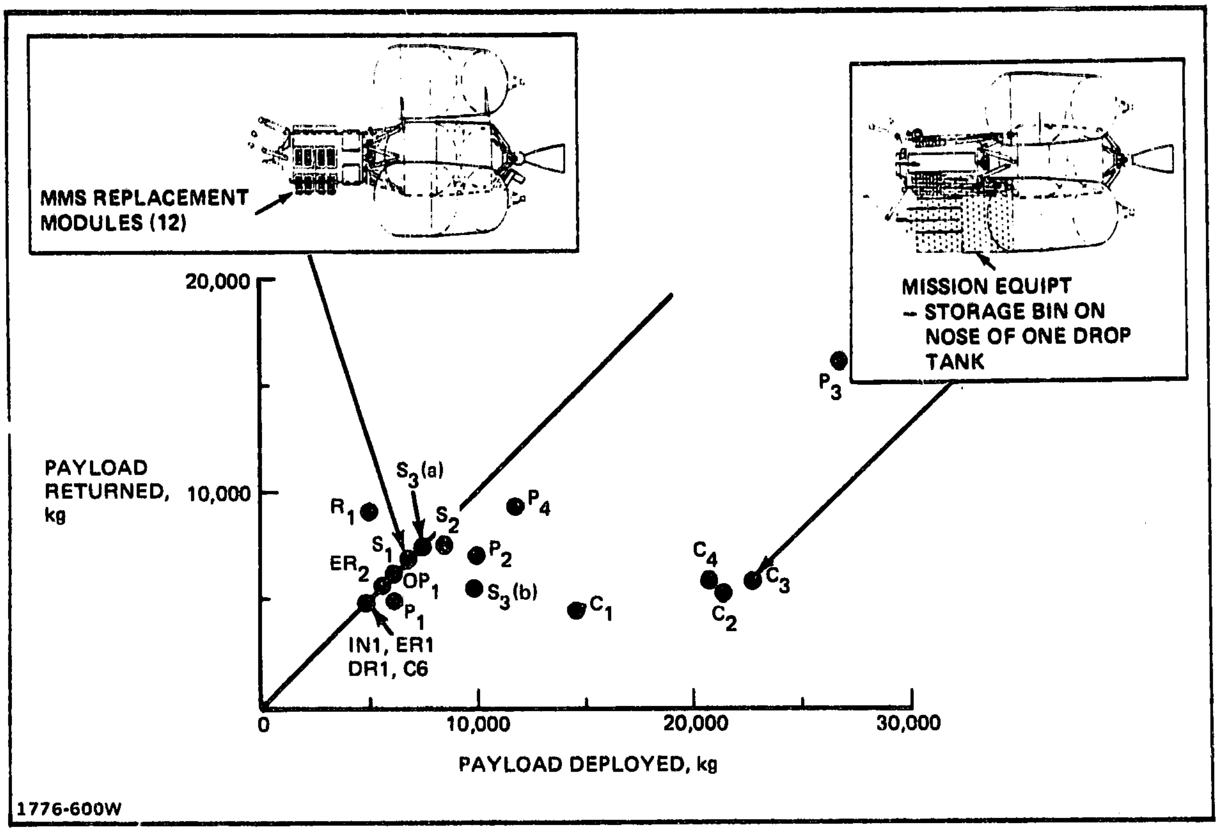


Fig. 3-7 MOTV Generic Mission Payload Requirements

MISSION	ON-ORBIT ΔV,FPS	
	MAIN	RCS
S1	1490	460
ER2	235	100
P2	35	100
P4	35	100
DR1	1460	370
C3	20	100
C6	35	580

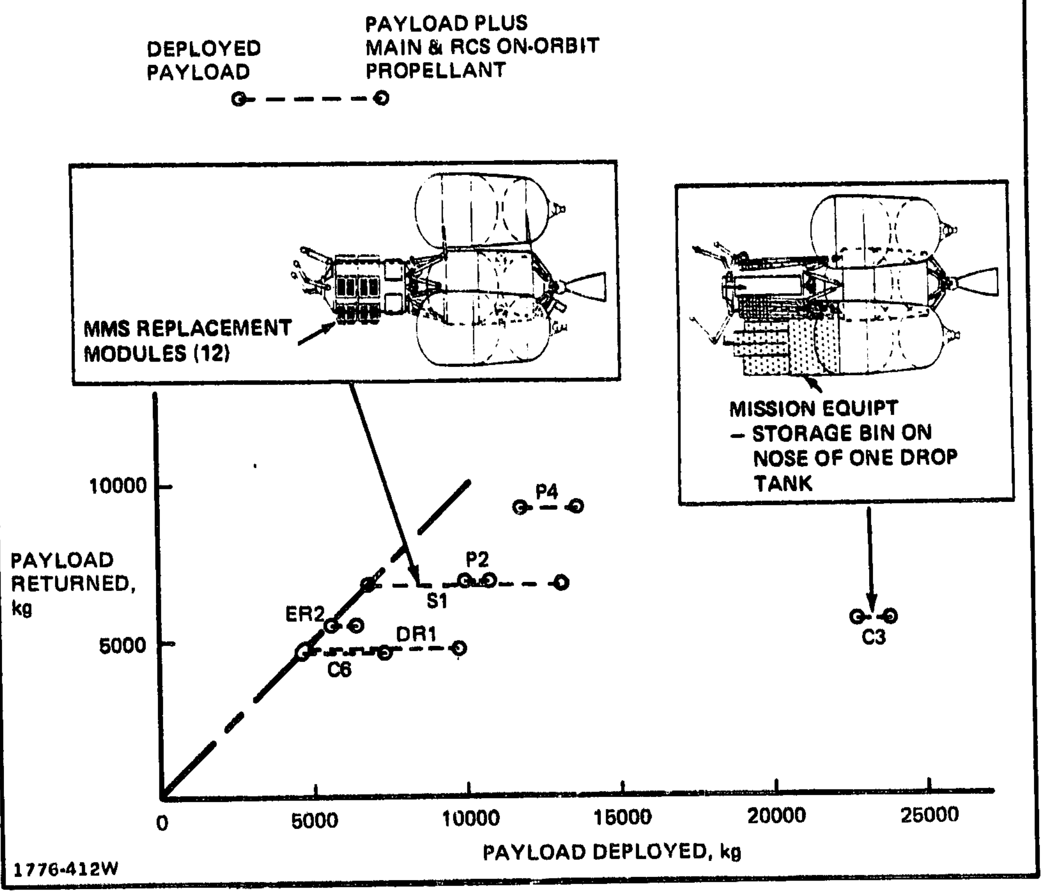


Fig. 3-8 MOTV Generic Mission Payload Requirements

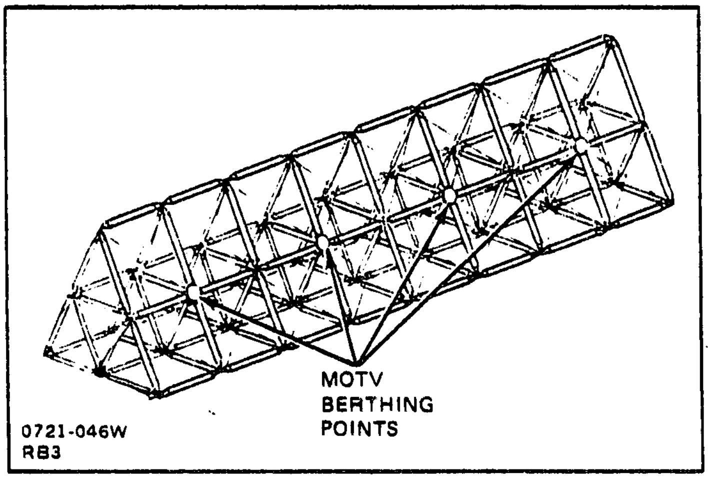
4 – GENERIC MISSION DESCRIPTION

This section presents a vivid description of each of the basic 20 generic mission scenarios. Aided by these descriptions, the role and subsequent configuration of the MOTV for each of the missions may be readily visualized and subject to further study.

4.1 GENERIC MISSION IN1 - INSPECTION OF A GEO ENVIRONMENTAL SATELLITE

Mission Description: A large-scale GEO environmental interaction experiment platform similar to that depicted in the figure is revisited two years after it was initially deployed. The purpose of the revisit is to inspect material samples left on the satellite, replace some of them with new ones, and retrieve others for further analysis back on earth. In addition, standard servicing of the satellite's subsystems such as RCS fluid replenishment would also be done.

Characteristics:



Weight	7000 kg
Size	
Length	100 m
Width.	20 m
Power	RTG
Orbit	GEO
Timeframe	Late 80s
Life/Servicing Period	20/1 yr

Rationale for MOTV Use:

- Man is required to inspect and change material samples and depends on the results of his inspection
- Servicing of the satellite subsystems such as fluid replenishment for RCS is simpler with man-in-the-loop.

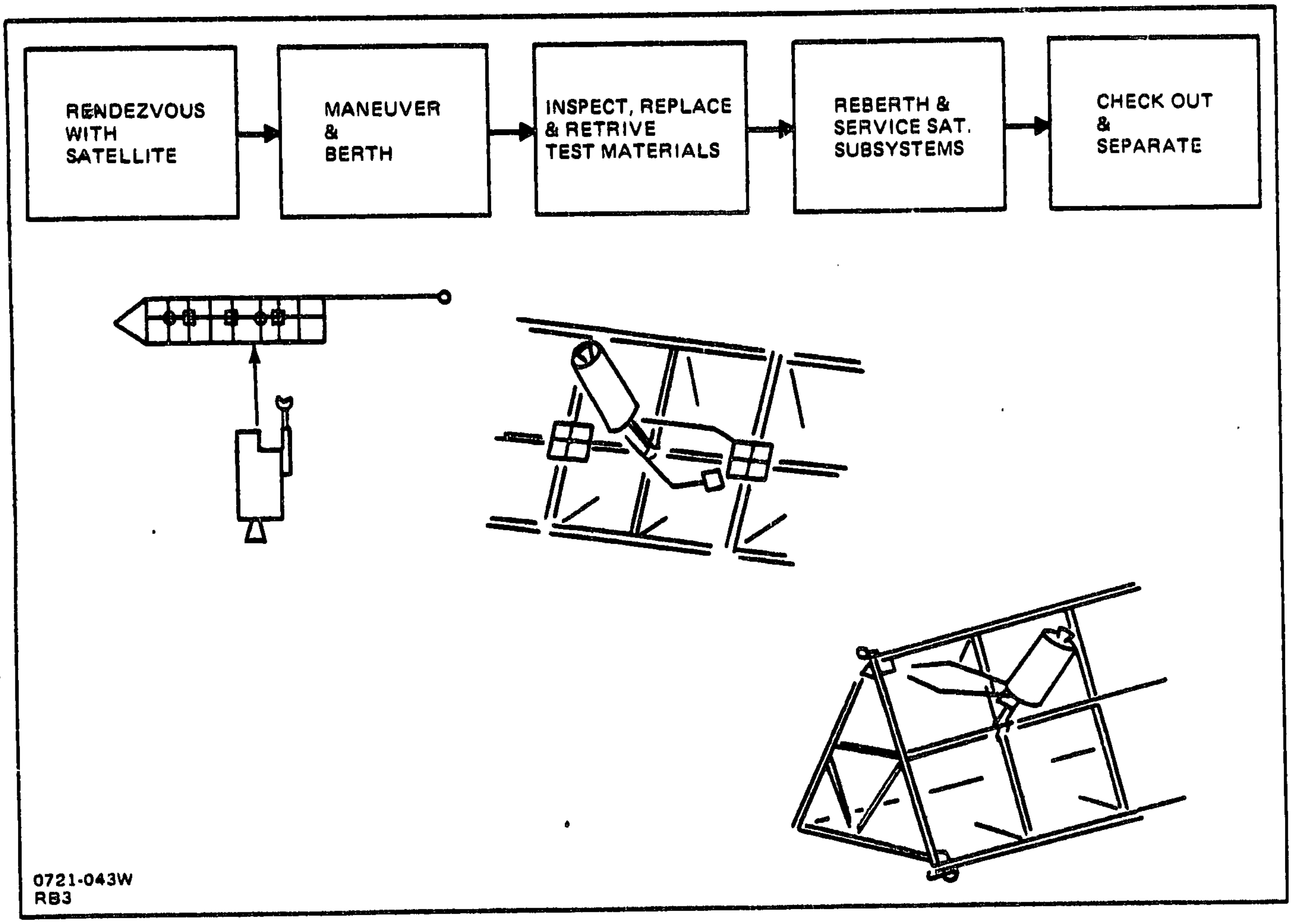


Fig. 4.1-1 IN1-Inspection of a GEO Environmental Satellite

ACTIVITY/FUNCTION	TIME HR:MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MANEUVER & BERTH	(1:00)	IVA		ALIGN G & N, ACTIVATE TV, ACQUIRE & TRACK TARGET, VERIFY STATS OPERATE C & DS	
– PREPARE FOR FINAL APPROACH					SPACE TUG DATA
– MANEUVER TO INSPECT SATELLITE	:45				
– MANEUVER TO BERTHING ATTITUDE					
– ACTIVATE & POSITION BERTHING SYS	:05				
– PERFORM CLOSING MANEUVER	:10				SPACE TUG
– CAPTURE & SECURE SATELLITE BERTHING					
• INSPECT, REPLACE & RETRIEVE TEST MATERIALS	(6:40)	IVA		OPERATE MANIPULATOR & TRAY RETENTION DEVICES	5 EXP. TRAYS x 3 LOCATIONS x 50 kg/TRAY=450 kg
– ACTIVATE & POSITION MANIPULATORS (2)	:10				
– INSPECT EXPERIMENT TRAYS	:20				
– UNSTOW & MOVE NEW EXPMT TRAYS TO SAT.	:20				
– ENGAGE SAT. TRAY WITH RETENTION DEVICE	:05				MRWS DATA
– RELEASE, REMOVE & SWING SAT. TRAY TO SIDE	:30				
– POSITION & INSTALL REPLACEMENT TRAY	:30				
– TRANSLATE & STOW RETRIEVED TRAY	:20				2:05 EA.–1 LOCATION @ 2ND BERTH
– REPLACE & RETRIEVE TRAYS AT 2 OTHER LOCATIONS	4:10				
– SAFE/STOW MANIPULATORS	:15				
• REBERTH & SERVICE SAT. SUBSYSTEMS	(7:30)	IVA		C/O SAT. SUB/SYS OPERATE & MONITOR MANIPULATOR	
– RELEASE BERTHING DEVICE	:10				
– MANEUVER TO NEXT BERTHING POSITION					
– REBERTH & REPOSITION MANIPULATORS	:20				
– REMOVE & STOW RCS PROPELLANT TANKS	:40		1		
– UNSTOW, INSTALL & C/O REPLACEMENT TANKS	:50		1		1:30 EA – REBERTH FOR 2 LOCATIONS
– REMOVE & REPLACE RCS TANKS AT 3 OTHER LOCATIONS	4:30				
– SAFE/STOW MANIPULATORS	:15				
– RELEASE & REBERTH TO NEXT RCS POSITION	:20		1		
– ACTIVATE MANIPULATORS & SAFE/STOW AT NEXT	:25		1		
• CHECK OUT & RELEASE SPACECRAFT	(1:10)	IVA			
– CHECK OUT SAT. SUBSYSTEM	:15		1		
– RELEASE BERTHING DEVICE			1		
– SAFE/STOW BERTHING DEVICE	:20		1		
– MANEUVER TO VERIFY SAT. CONFIG.			1		
– SUPPORT SAT. SPACE–GROUND C/O	:35		1		
TOTAL	(16:20)				

0721-044W
RB3

Fig. 4.1-2 IN1-Functions Times & Tasks

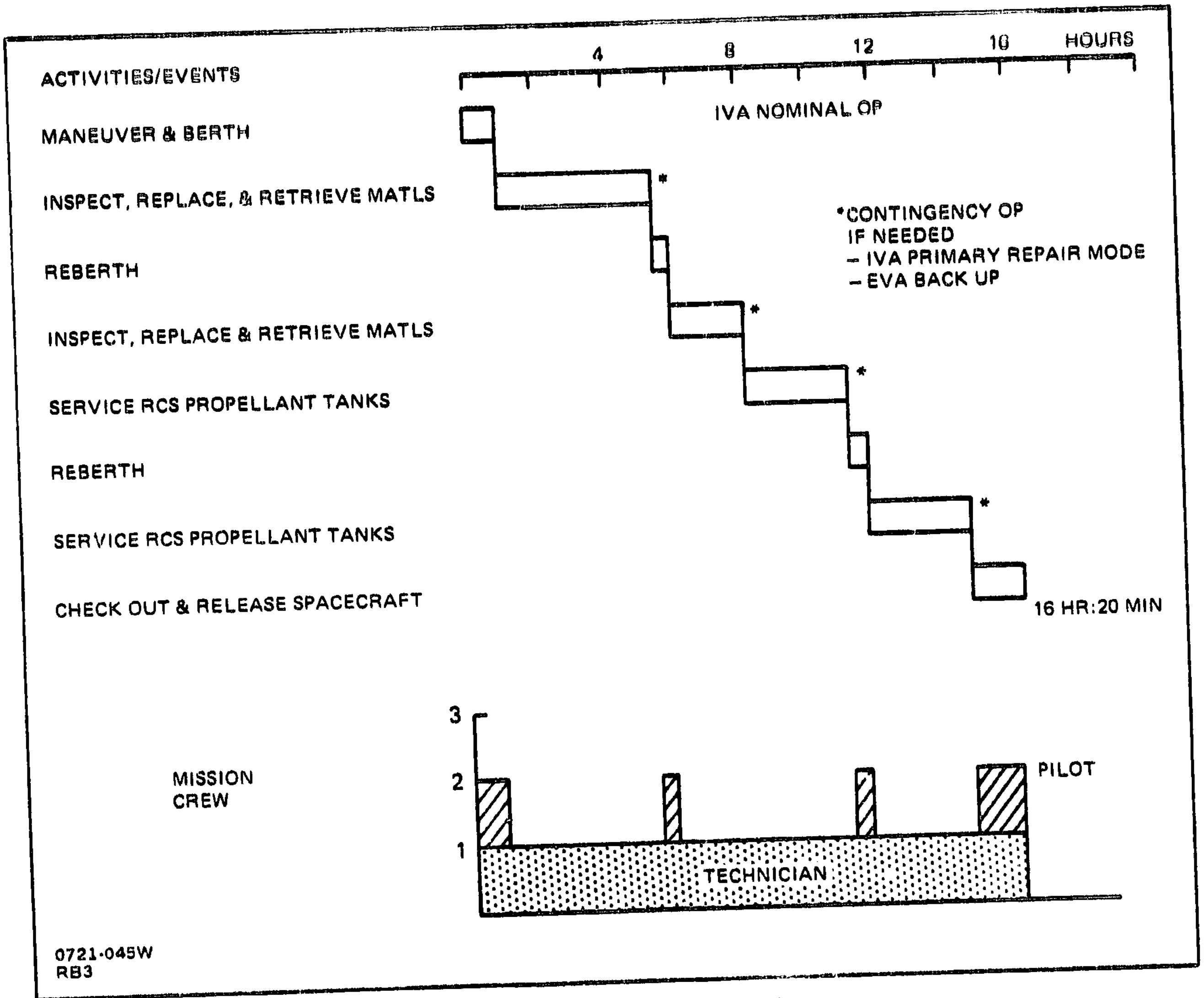


Fig. 4.1-3 IN1-Timeline & Crew Requirements

4.2 GENERIC MISSION S1, DESIGN REFERENCE MISSION (DRM) - SERVICING OF FOUR COMMUNICATIONS SATELLITES USING MMS MODULES.

Mission Description: Four communications satellites, all using standard Multimission Module Spacecraft (MMS) type hardware for subsystem support functions and all identical to each other, are serviced by the MOTV. The satellites are all located in GEO, 90° apart. Periodically, the MOTV visits each of these satellites and services the MMS type subsystems as depicted in the figure below. Modular replacement of each of the MMS subsystems is done on an "as required" basis. After servicing and checkout of each satellite the MOTV returns to earth with the used MMS modules, jettisoning them with the last propellant drop tank just before rendezvous with the STS in earth orbit.

Characteristics:

Weight . . . . 421 kg per Sat.

Size

Length . . . . 1.2 m

Width. . . . . 1.2 m

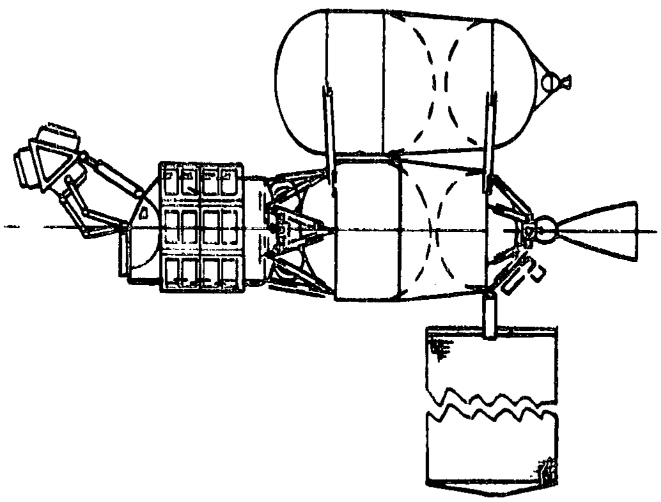
Height . . . . 0.46 m

Power . . . . 1.2 kW Avg

Orbit. . . . . GEO

Timeframe . . . . Late 80s

Life/Service Period . . . 20/2 Yr



Rationale for MOTV Use:

- Servicing satellites remotely using teleoperators operated from earth is more complex, less versatile, and less reliable than having man "on site" to perform this function
- Servicing and checkout is more thorough with man on-site, and contingencies can be more readily handled.

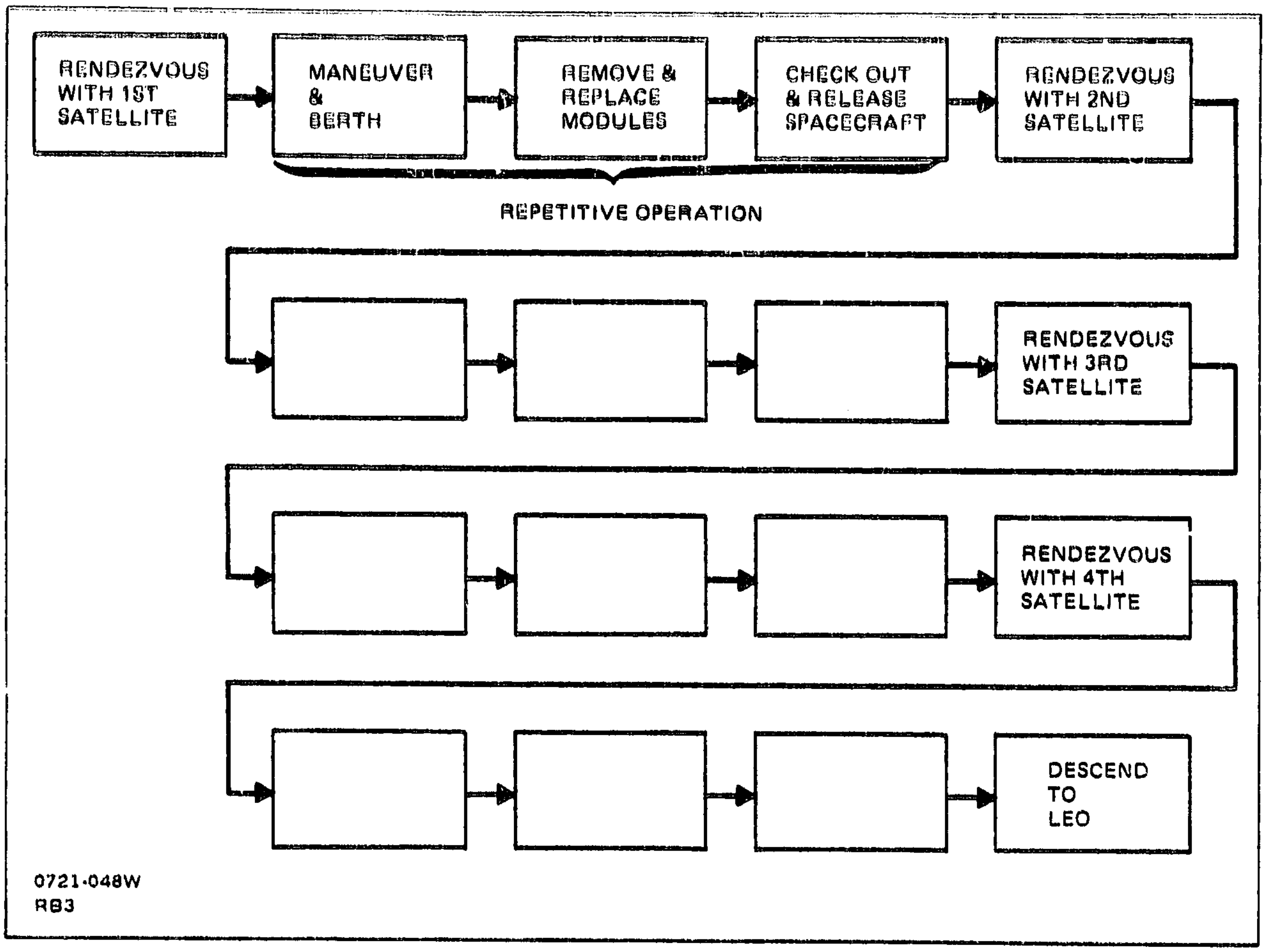


Fig. 4.2-1 S1-Modular Level Servicing (4 Geo Satellites – 90° Apart)

ACTIVITY/FUNCTION	TIME HR:MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MANEUVER & BERTH WITH SATELLITE 1	(1:00)	IVA		ALIGN G & N ACTIVATE TV ACQUIRE & TRACK TARGET VERIFY STABILITY, OPERATE C & DS – SAFE ? SATELLITE SYSTEM	
– PREPARE FOR FINAL APPROACH – MANEUVER TO INSPECT SATELLITE	:45				
– MANEUVER TO BERTHING ATTITUDE	:05				
– ACTIVATE & POSITION BERTHING SYSTEM – PERFORM CLOSING MANEUVER – CAPTURE & SECURE SATELLITE BERTHING	:10				
• REMOVE & REPLACE MODULES	(3:35)	IVA			
– ACTIVATE & POSITION MANIPULATORS (2)	:10				
– UNSTOW MMS MODULE & MOVE TO SATELLITE	:20				
– ENGAGE MODULE HOLDER ON SATELLITE	:05				
– REMOVE MMS MODULE & SWING TO SIDE	:10				
– SWING REPLACEMENT MODULE IN POSITION & ENGAGE	:05				
– RESTOW & SECURE USED MODULE	:20				
– ROTATE SAT. FOR MODULE SERVICING	:10				
– REMOVE & REPLACE 2 OTHER MODULES	2:00				1:00 EA.
– SAFE/STOW MANIPULATORS	:15				
• CHECK OUT & RELEASE SPACECRAFT	(1:10)	IVA			
– CHECK OUT SATELLITE SYS – RELEASE BERTHING DEVICE	:15				
– SAFE/STOW BERTHING DEVICE – MANEUVER TO VERIFY SATELLITE CONFIG	:20				
– SUPPORT SATELLITE SPACE–GROUP C/O	:35				
• RENDEZVOUS TO SATELLITE NO. 2	(114:00)	IVA			4½ DAYS 90° SEPARATION
– PHASING ORBIT INSERTION – APOGEE ADJUST & COAST – PHASE ADJUST & COAST – CIRCULARIZATION – TERMINAL PHASE BRAKING	114:00				
• MANEUVER & BERTH TO SATELLITE NO. 2	1:00	IVA			
• REMOVE & REPLACE MODULES	3:35	IVA			
• C/O & RELEASE SATELLITE NO. 2	1:10	IVA			
• RENDEZVOUS TO SATELLITE NO. 3	114:00	IVA			
• SERVICE SATELLITE NO. 3	5:45	IVA			
• RENDEZVOUS TO SATELLITE NO. 4	114:00	IVA			
• SERVICE SATELLITE NO. 4	5:45	IVA			
TOTAL	(365:0[illegible])				

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RB3

Fig. 4.2-2 S1–Functions, Time, & Tasks

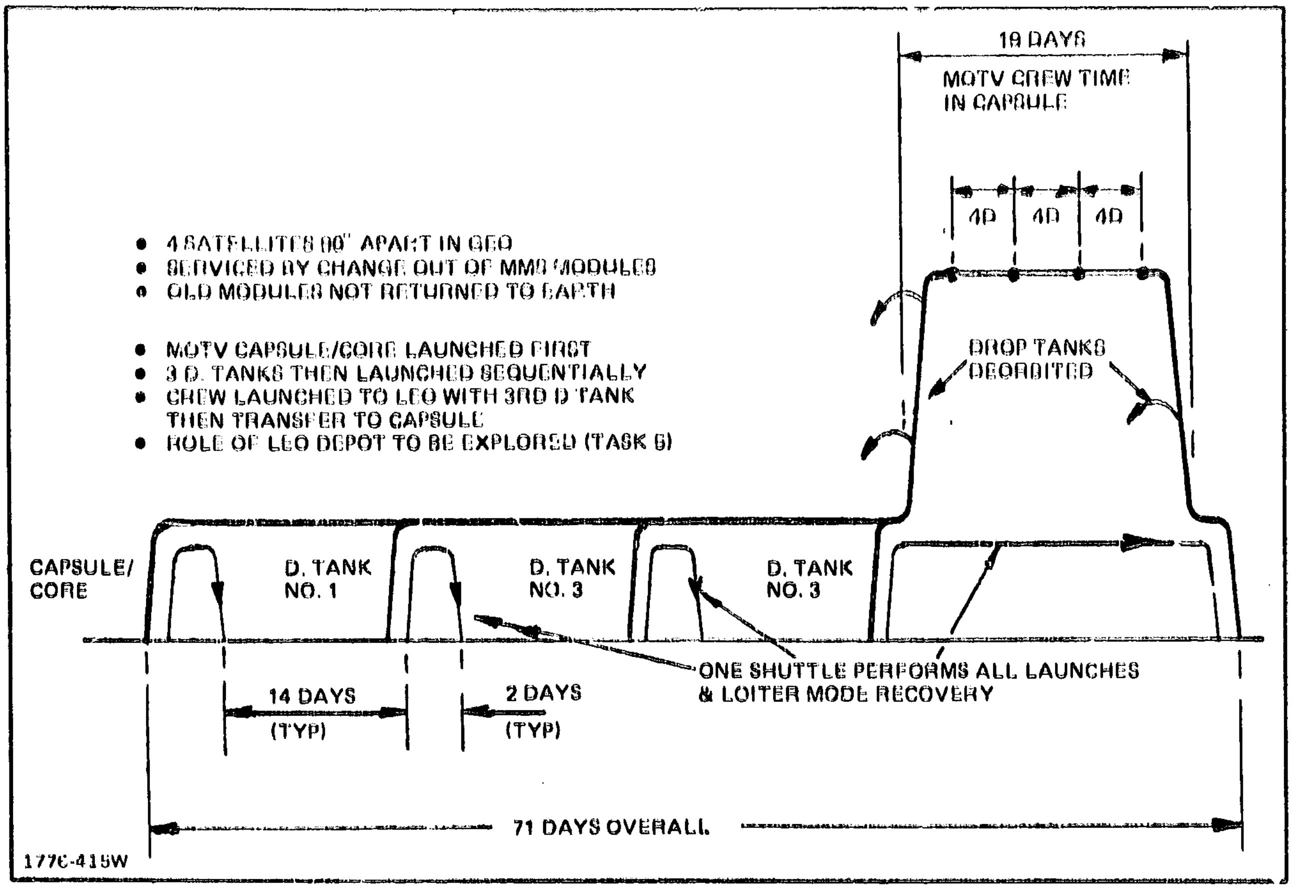

Fig. 4.2-3 Typical Overall Timeline S1

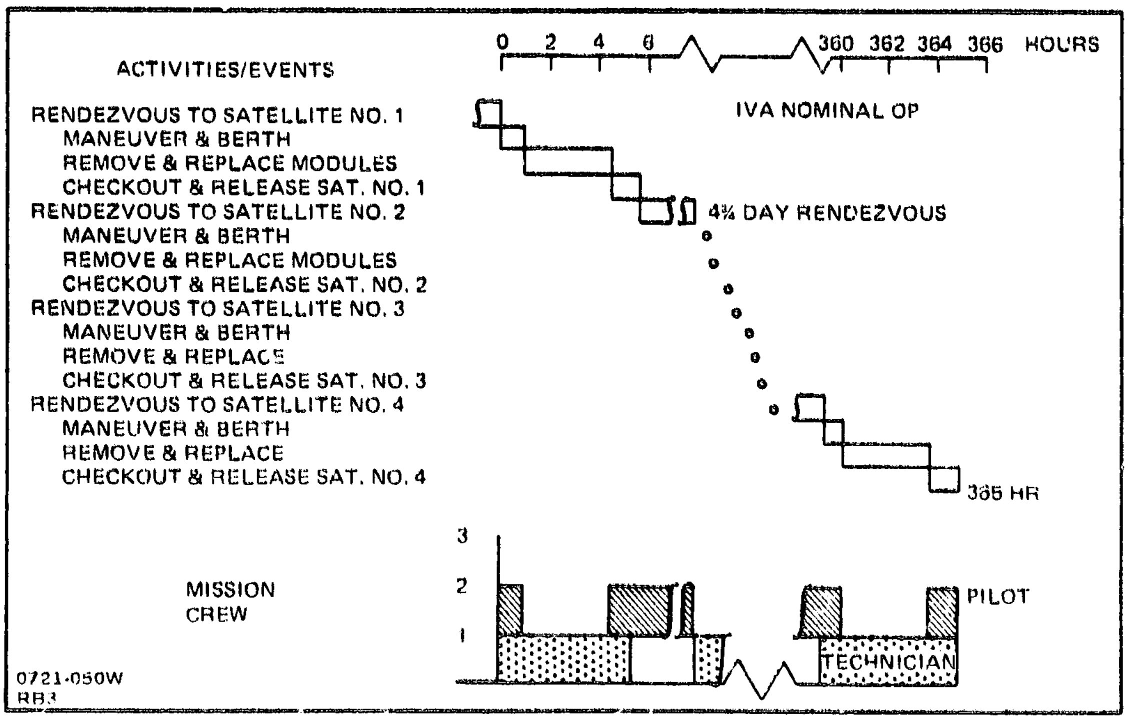

Fig. 4.2-4 S1-Timeline & Crew Requirements

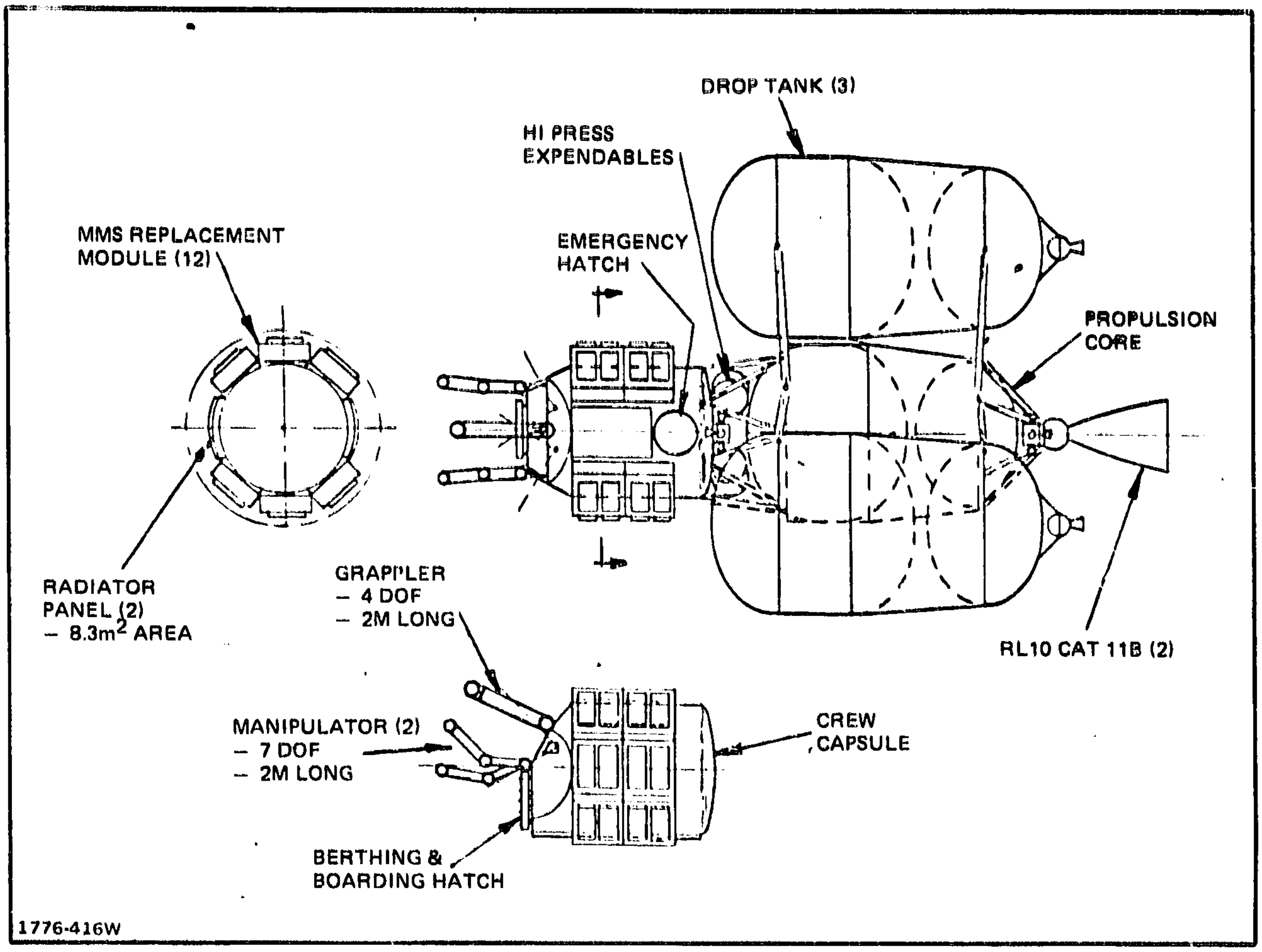

Fig. 4.2-5 MOTV Configuration For Mission S1

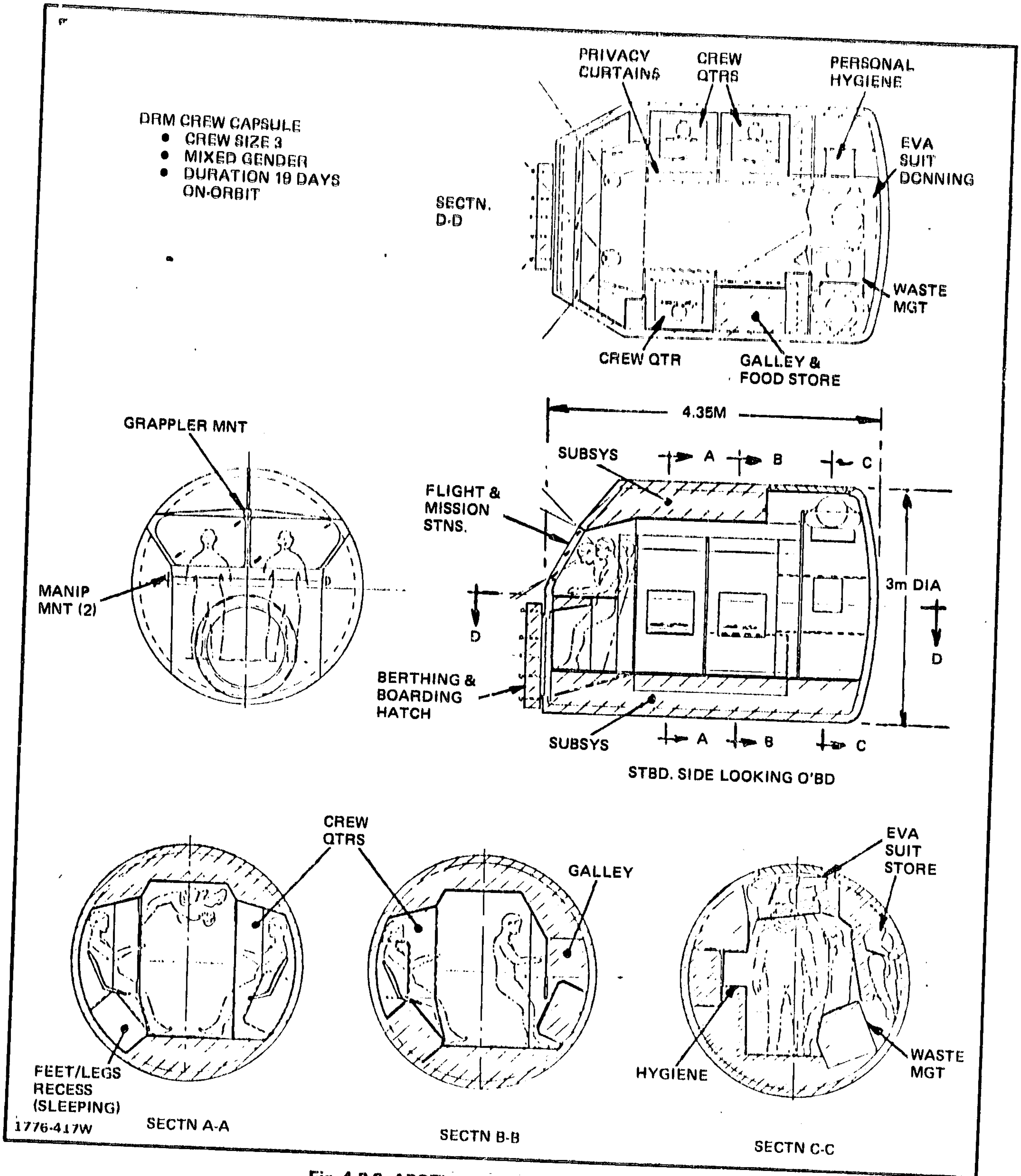

Fig. 4.2-6 APOTV Crew Module (3 Man) S1

	CREW CAPSULE	PROP'LS'N CORE	DROP TANKS (3)	MISSION EQUIP'T GENERAL PURPOSE	MISSION EQUIP'T DEDICATED
DRY WEIGHT	3951	3328	4725	773	120
CREW/CONSUMABLES RESERVES/RESIDS	577	51 296	 705		
BURNOUT WEIGHT	4528	3675	5430	773	120
MAIN PROP – (CAPACITY) – LOADING ACPS PROP MISC		(17,500) 13,404 2570 145	(81,810) 66,762		 1684
MOTV WEIGHT	4528	19,794	72,192	773	1804
TOTAL MOTV WEIGHT	← 99,091 →				

1776-418W

Fig. 4.2-7 S1 Summary Wt Statement, kg

CREW CAPSULE		WEIGHT, kg
STRUCTURE		1515
THERMAL PROT		48
EPS		25
AVIONICS		149
ECLS		524
CREW ACCOM		894
PROPULSION		6
RECOVERY		–
CONTINGENCY	(25%)	790
TOTAL DRY WEIGHT		3951
CREW	(3)	245
CONSUMABLES	(19 DAYS)	332
BURNOUT WEIGHT		4528

NOTES
- MANIPULATORS, ETC., CHARGED TO GEN PURPOSE MISSION EQUIP.
- EPS SUBSYS IS POWER DISTR ONLY – REMAINDER OF SUBSYS IN PROP. CORE

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Fig. 4.2-8 S1 Wt Statement (Crew Capsule)

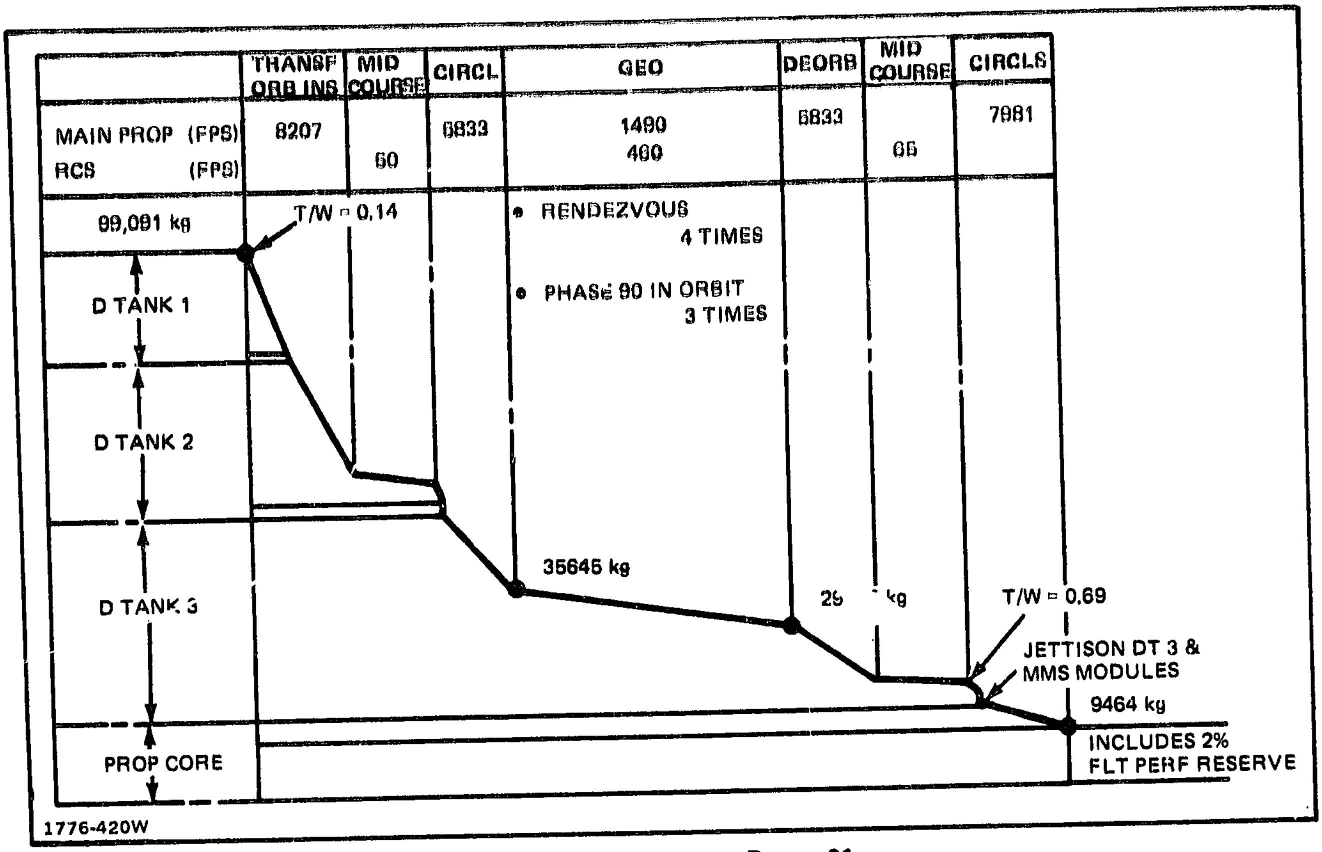


Fig. 4.2-9 Performance Data – S1

	CREW CAPSULE	PROPULSION CORE	DROP TANKS (3)	TOTALS
MANAGEMENT				0.42
CREW PROVISIONS	0.06			0.06
TURNAROUND			–	2.20
FUEL		0.02	0.09	0.11
DROP TANKS			3.45	3.45
MISSION OPS				1.80
STS OPS				110.10
TOTAL				118.14

• 4 SATELLITES SERVICE FOR $30M EA
• COMSAT STUDY ~ SATELLITES COST $80M EA

Fig. 4.2-10 Typical Cost per Mission ~ Service Mission SI (Constant '79 $ M)

4.3 GENERIC MISSION S2 - SERVICE & UPDATE FIVE COMSAT COMMUNICATIONS SATELLITES

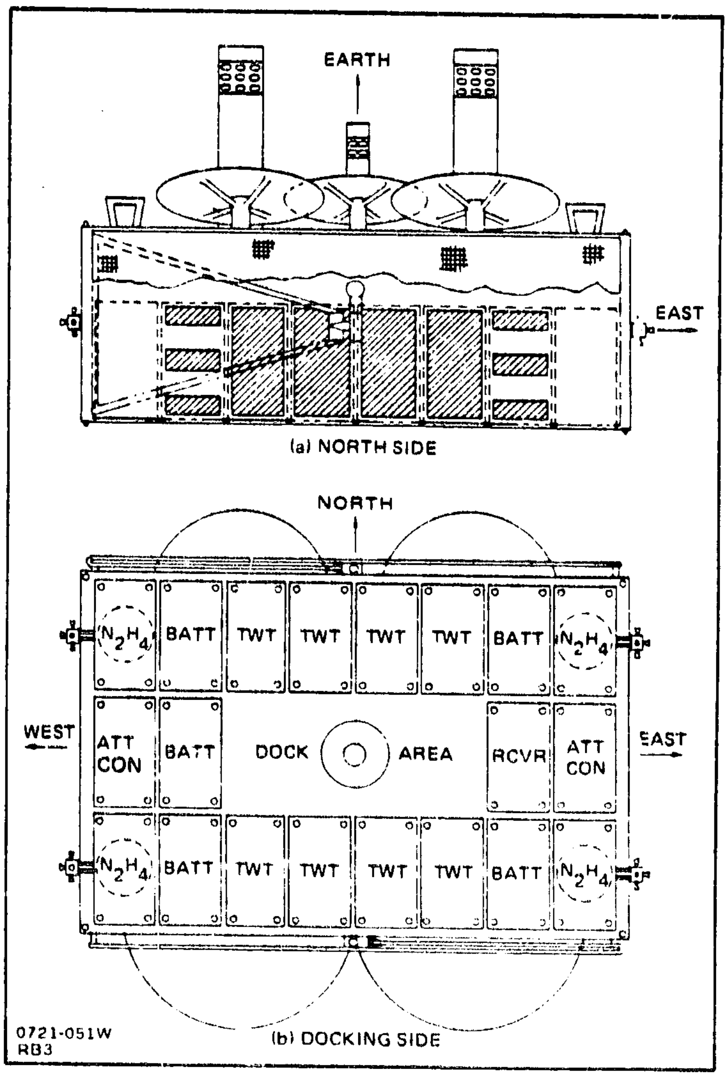
Mission Description: Five Comsat Communications Satellites are deployed in GEO. The entire system is routinely serviced and its electronics updated. The routine servicing tasks involve inspection and replacement of failing electronic black boxes as well as scheduled replacement of electronic components and replenishment of RCS fluids. The updating tasks involve replacement of outdated electronics packages with updated ones. This mission differs from the previous one, in that serviced parts are replaced on a black box or component level rather than a modular level. The servicing operations are more complex and take longer to perform, as are the final checkout procedures.

Characteristics:

Weight	1230 kg
Size	
Length	4.5 m
Width	4.5 m
Power	2 kW
Orbit	GEO
Timeframe	1990s
Life/Servicing Period	20/2 yr
Update	4 yr

Rationale for MOTV Use:

- Same as Generic Mission S1



MODULE	COMPONENT WEIGHT (lb)	STRUCTURE, HARNESS, CONNECTORS (lb)	LATCH/ ATTACH MECHANISMS (lb)	TOTAL WEIG… (lb)	NO. OF MODULES (lb)	SYSTEM TOTAL (lb)
TWT*	60	12	14	86	8	688
RECEIVER	66	13	14	93	1	93
ATTITUDE CONTROL	60	12	14	86	2	172
BATTERY AND T&C	75	14	14	103	2	206
BATTERY AND CONVERTER	60	12	14	86	2	172
PROPULSION*	120	21	14	155	4	620
						1951

*MISSION HDWR

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Fig. 4.3-1 S2-Modularized Spacecraft Module Weights Present Technology

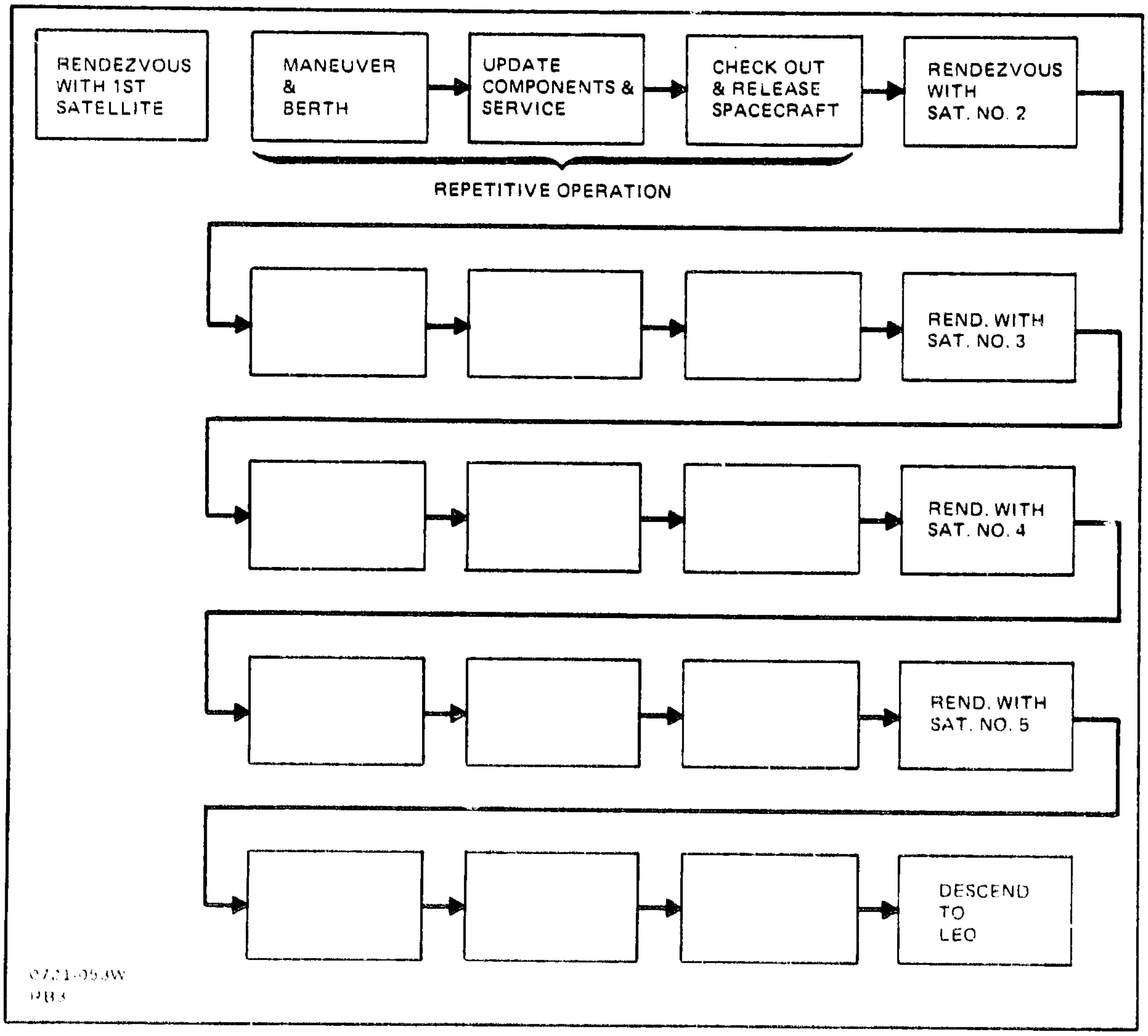

Fig. 4.3-2 S2-Component Level Service & Update 5 Geo Satellites – 72° Apart (S/A Power System)

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MANEUVER & BERTH WITH SAT. NO. 1	(1:00)	IVA			
– PREPARE FOR FINAL APPROACH					
– MANEUVER TO INSPECT SATELLITE	:45				
– MANEUVER TO BERTHING ATTITUDE					
– ACTIVATE & POSITION BERTHING SYS	:05				
– PERFORM CLOSING MANEUVER	:10				
– CAPTURE & SECURE SATELLITE BERTHING					
• UPGRADE COMPONENTS & SERVICE	(15:20)	IVA			
– C/O & SAFE SATELLITE S/S	:15				
– ACTIVATE & POSITION MANIPULATORS (2)	:10				
– C/O & UNSTOW NEW TWT WITH HANDLING FIXTURE	:15				
– TRANSLATE TO SAT & ENGAGE FIXTURE	:15				
– RELEASE & REMOVE OLD COMPONENT TO SIDE	:05				
– INSTALL & C/O REPLACEMENT COMPONENT	:20				
– RESTOW & SECURE OLD COMPONENT	:10				
– REMOVE & REPLACE 7 OTHER TRANSPONDER (TWT) UNITS	7:35				1:05 EA
– REMOVE & STOW 4 USED PROPELLANT TANKS	2:40				:40 EA
– UNSTOW & INSTALL REPLACEMENT RCS TANKS	3:20				:50 EA
– SAFE/STOW MANIPULATORS	:15				
• CHECKOUT & RELEASE SPACECRAFT	(1:10)	IVA			
– CHECKOUT SATELLITE SYSTEM	:15				
– RELEASE BERTHING DEVICE					
– SAFE/STOW BERTHING DEVICE					
– MANEUVER TO VERIFY SATELLITE CONFIG	:20				
– SUPPORT SATELLITE SPACE-GROUND C/O	:35				
• RENDEZVOUS TO SATELLITE NO. 2	91:10	IVA			~ 3.8 DAYS 72° SEPARATION
• SERVICE SATELLITE NO. 2	17:30	IVA			
• RENDEZVOUS TO SATELLITE NO. 3	91:10	IVA			
• SERVICE SATELLITE NO. 3	17:30	IVA			

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Fig. 4.3-3 S2–Functions, Time, & Tasks

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• RENDEZVOUS TO SATELLITE NO. 4	91:10	IVA			
• SERVICE SATELLITE NO. 4	17:30	IVA			
• RENDEZVOUS TO SATELLITE NO. 5	91:10	IVA			
• SERVICE SATELLITE NO. 5	17:30	IVA			
TOTAL	(452:10)				

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RB3

Fig. 4.3-3 S2–Functions, Time, & Tasks (Contd)

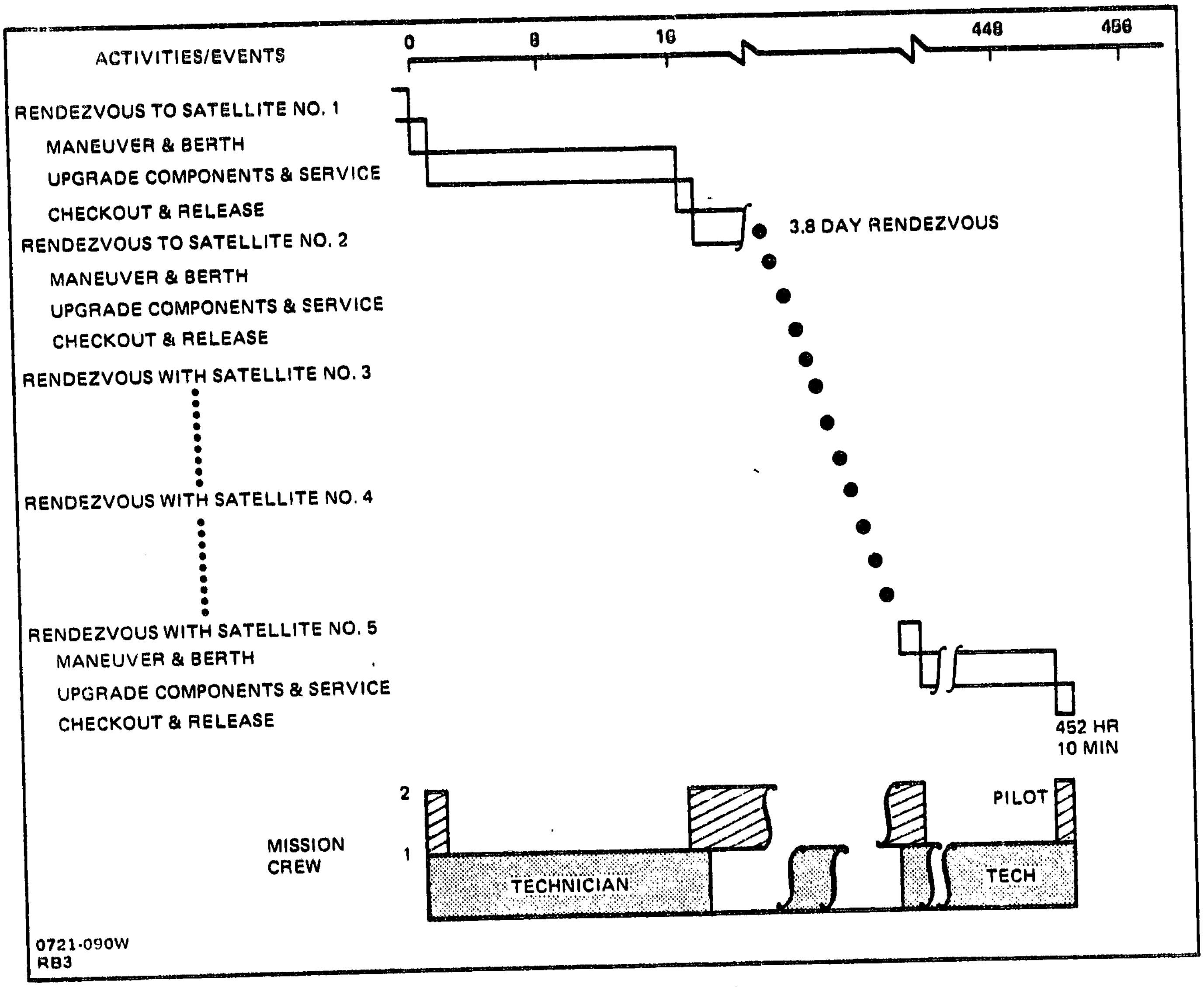


Fig. 4.3-4 S2-Timeline & Crew Requirements

4.4 GENERIC MISSION S3 – SERVICE & UPDATE A SYSTEM OF FIVE NUCLEAR POWERED SPACE-BASED RADAR

Mission Description: Five Large Space-Based Radar Systems are deployed in GEO spaced 72° apart. The entire system is serviced, and periodically updated. The servicing involves replacement of failing electronic black boxes, power supply control and distribution components, and replenishment of ACS fluids. The updating tasks involve replacement of outdated electronics, whereas servicing the nuclear power supply is done at ten year intervals and involves replacing the core. This mission differs from missions S1 and S2 in that special care must be taken to avoid radiation exposure from the nuclear power plant during servicing and updating operations. A remotely controlled flyer is used for removal of the old reactor core.

The generic S3 mission has been divided into missions S3(a) and S3(b). Mission S3(a) deals with the electronic and ACS servicing of the five satellites. Mission S3(b) consists of the replacement of a single satellite's reactor unit.

Characteristics:

Weight . . . . 14,000 kg

Size . . . . 300 m dia

Power . . . . 20 kW_e

Orbit. . . . . GEO

Timeframe 1990s

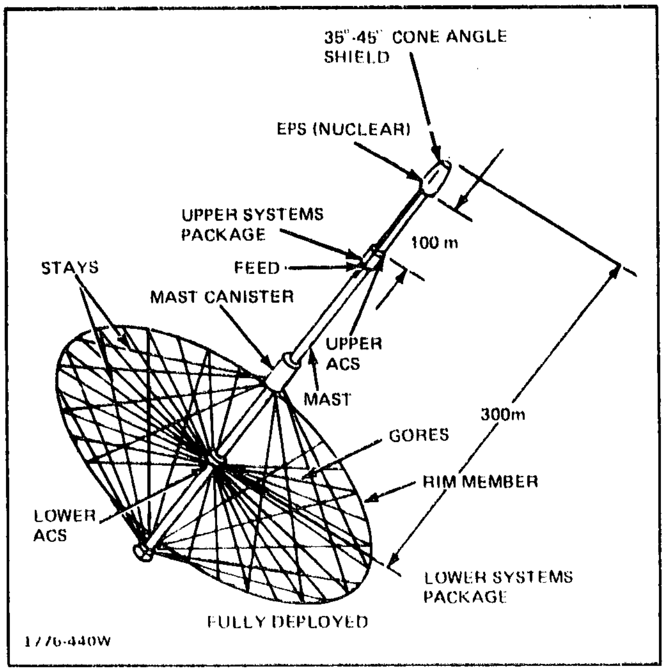
Life/Servicing Period . . . . 20/5 yr

Update Period . . . . 5 yr

Nuclear Service Period . . . 10 yr

Rationale for MOTV Use:

- Same as Generic Mission S1



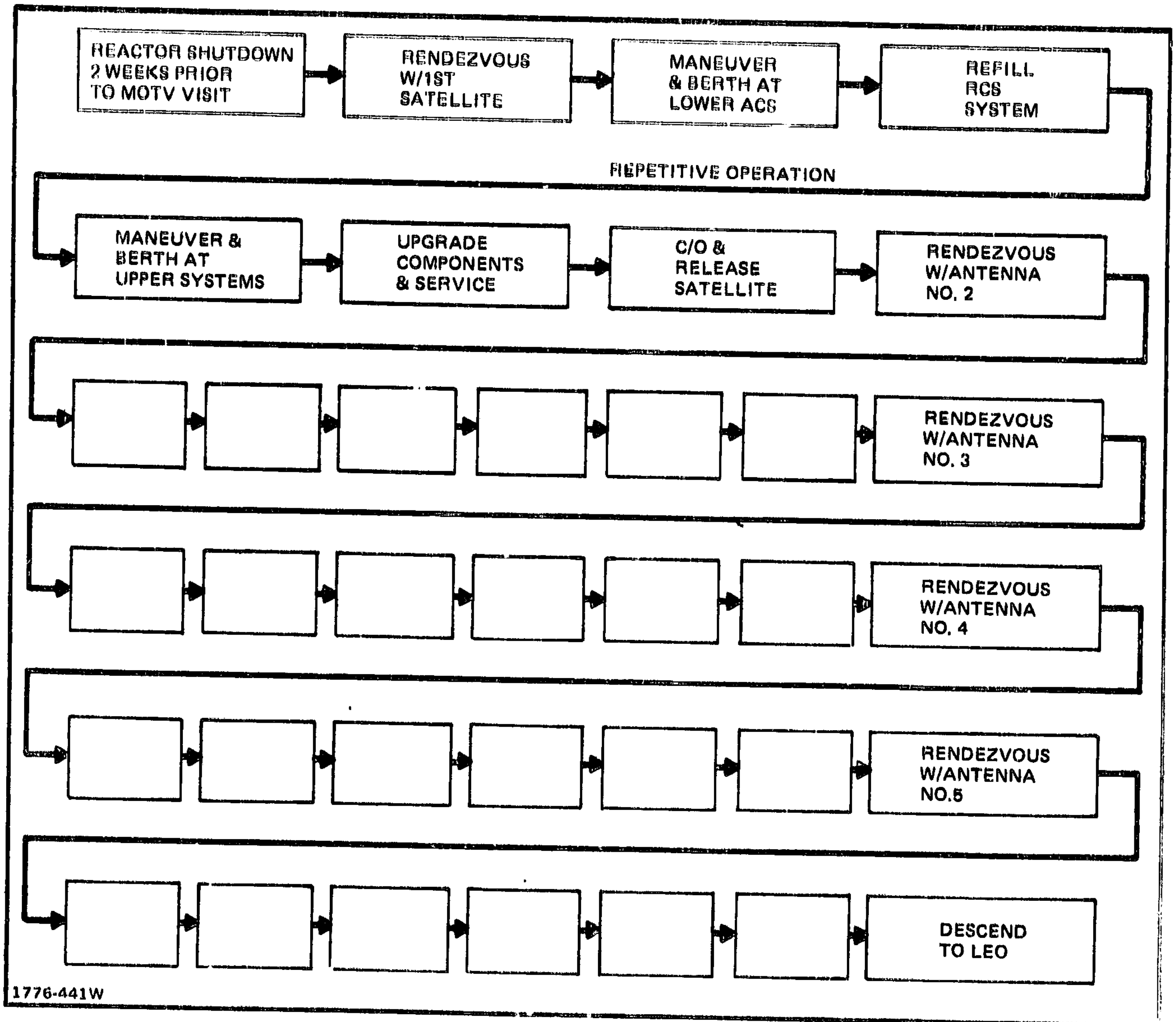


Fig. 4.4-1 S3(a) Component Level Service & Update 5 GEO Satellites – 72° Apart (Electronics Updating)

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MANEUVER & BERTH WITH SAT. NO. 1 (LOWER ACS SYSTEM)	(1:00)				
– PREPARE FOR FINAL APPROACH	:45	1 VA	1	OPERATE MOTV FLT. SYS.	
– MANEUVER TO INSPECT SATELLITE		1 VA	1		
– MANEUVER TO BERTHING ALTITUDE		1 VA	1	OPERATE GRAPPLER CONTROL	
– ACTIVATE & POSITION BERTHING SYS.	:05	1 VA	2		
– PERFORM CLOSING MANEUVER	:10	1 VA	2		
– CAPTURE & SECURE SATELLITE BERTHING		1 VA			
• REFILL RCS SYSTEM	(2:50)				
– C/O & SAFE SATELLITE S/S	:15	1 VA	2		
– ACTIVATE & POSITION MANIPU-LATORS (2)	:10	1 VA	1	OPERATE MANIPU-LATOR CONTROLS	
– UNSTOW & CONNECT RCS FLUID TANK	1:00	1 VA	1		
– REFILL RCS SYSTEM	:25	1 VA	1		VIA REFILL LINE EXTENDING PAST ANTENNA WIRES
– DISCONNECT & STOW FLUID TANKS	:45	1 VA	1		
– SAFE/STOW MANIPULATORS	:15	1 VA	1		
• RELEASE SATELLITE	(:15)				
– RELEASE BERTHING DEVICE	:05	1 VA	1	OPERATE GRAP-PLER CONTROLS	
– SAFE/STOW BERTHING DEVICE	:10	1 VA	1		
• MANEUVER & BERTH AT UPPER SYSTEMS	(:40)				
– MANEUVER TO INSPECT SATELLITE	:40	1 VA	1	OPERATE FLT. SYS.	
– MANEUVER TO BERTHING ALTITUDE	:40	1 VA	1		
• UPGRADE COMPONENTS & SERVICE	(10:25)				
– C/O & SAFE SATELLITE S/S	:10	1 VA	2		INCLUDES UPPER ACS
– ACTIVATE & POSITION MANIPU-LATORS	:10	1 VA	1		

1776-442W(1)

Fig. 4.4-2 S 3(a) Functions, Time, & Tasks

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
– C/O & UNSTOW NEW BLACK BOX	:20	1 VA	1	OPERATE MANIPULATOR CONTROLS	
– TRANSLATE TO SATELLITE	:05	1 VA	1		
– RELEASE & REMOVE OLD COMPONENT TO SIDE	:20	1 VA	1		
– INSTALL & C/O NEW UNIT	:35	1 VA	2		
– RESTOW & SECURE OLD UNIT	:15	1 VA	1		
– REMOVE & REPLACE 4 OTHER BLACK BOXES	6:20	1 VA			1:35 EA
– UNSTOW RCS RODS	:10	1 VA	1		ION RCS SYSTEM
– REFILL UPPER ACS PACKAGE	1:45	1 VA	1		
– SAFE/STOW MANIPULATORS	:15	1 VA	1		
• CHECKOUT & RELEASE SATELLITE	(1:35)				
– C/O SATELLITE SYSTEMS	:25	1 VA	2	OPERATE & MONITOR CONTROLS & DISPLAYS	
– RELEASE BERTHING DEVICE	} :15	1 VA	1		
– SAFE/STOW BERTHING DEVICE		1 VA	1		
– MANEUVER TO VERIFY SATELLITE CONFIGURATION	:10	1 VA	1		
– SUPPORT SATELLITE SPACE-GROUND C/O	:45	1 VA	1	MONITOR ANTENNA SYSTEM	
• RENDEZVOUS TO SATELLITE NO. 2	91:10				~ 3.8 DAYS
• SERVICE SATELLITE NO. 2	16:45				72° SEPARATION
• RENDEZVOUS TO SATELLITE NO. 3	91:10				
• SERVICE SATELLITE NO. 3	16:45				
• RENDEZVOUS TO SATELLITE NO. 4	91:10				
• SERVICE SATELLITE NO. 4	16:45				
• RENDEZVOUS SATELLITE NO. 5	91:10				
• SERVICE SATELLITE NO. 5	16:45				
TOTAL	(448:55)				

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Fig. 4.4-2 S 3(a) Functions, Time, & Tasks (Contd)

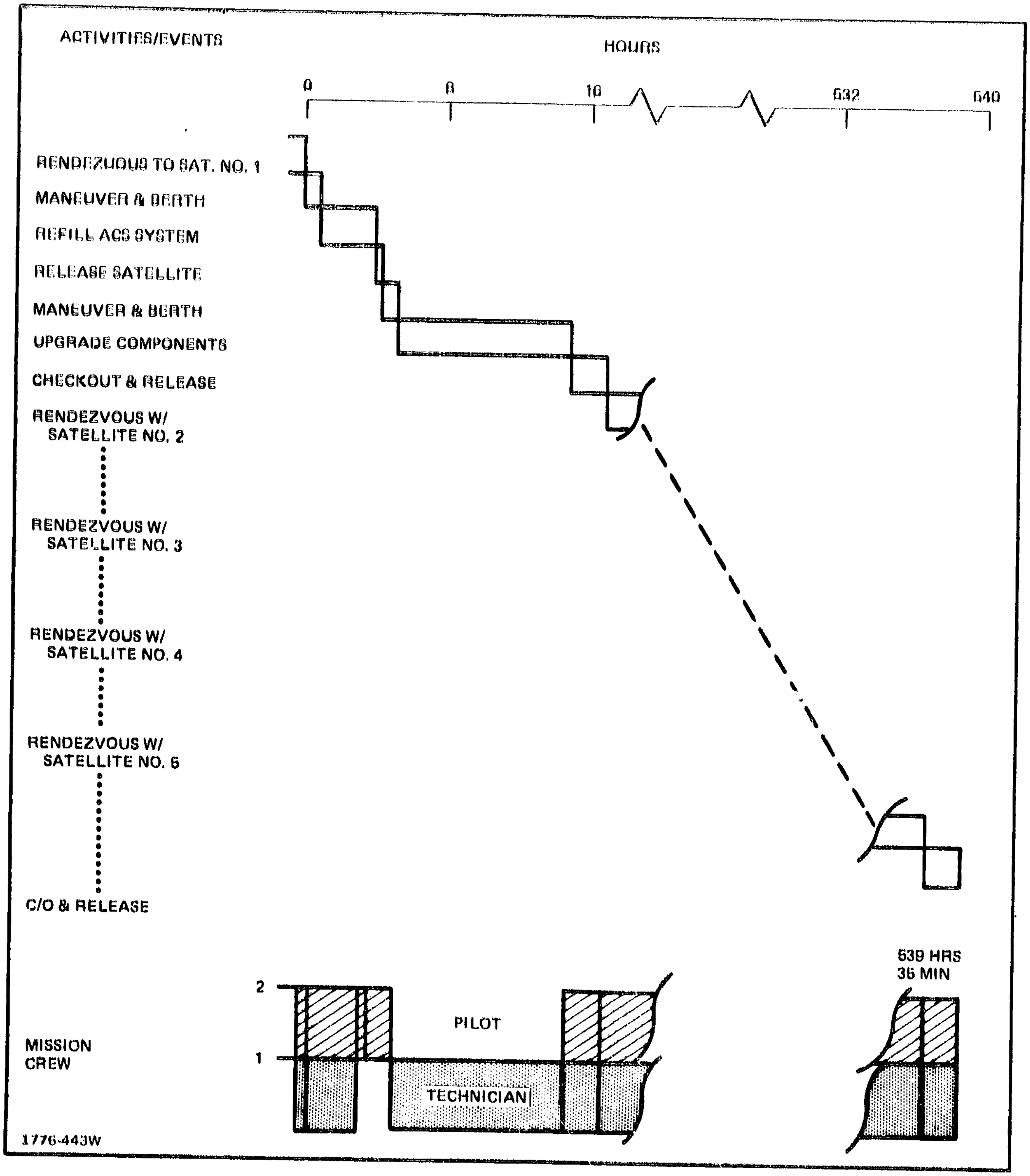


Fig. 4.4-3 S3(a) Time Line & Crew Requirements: Component Servicing

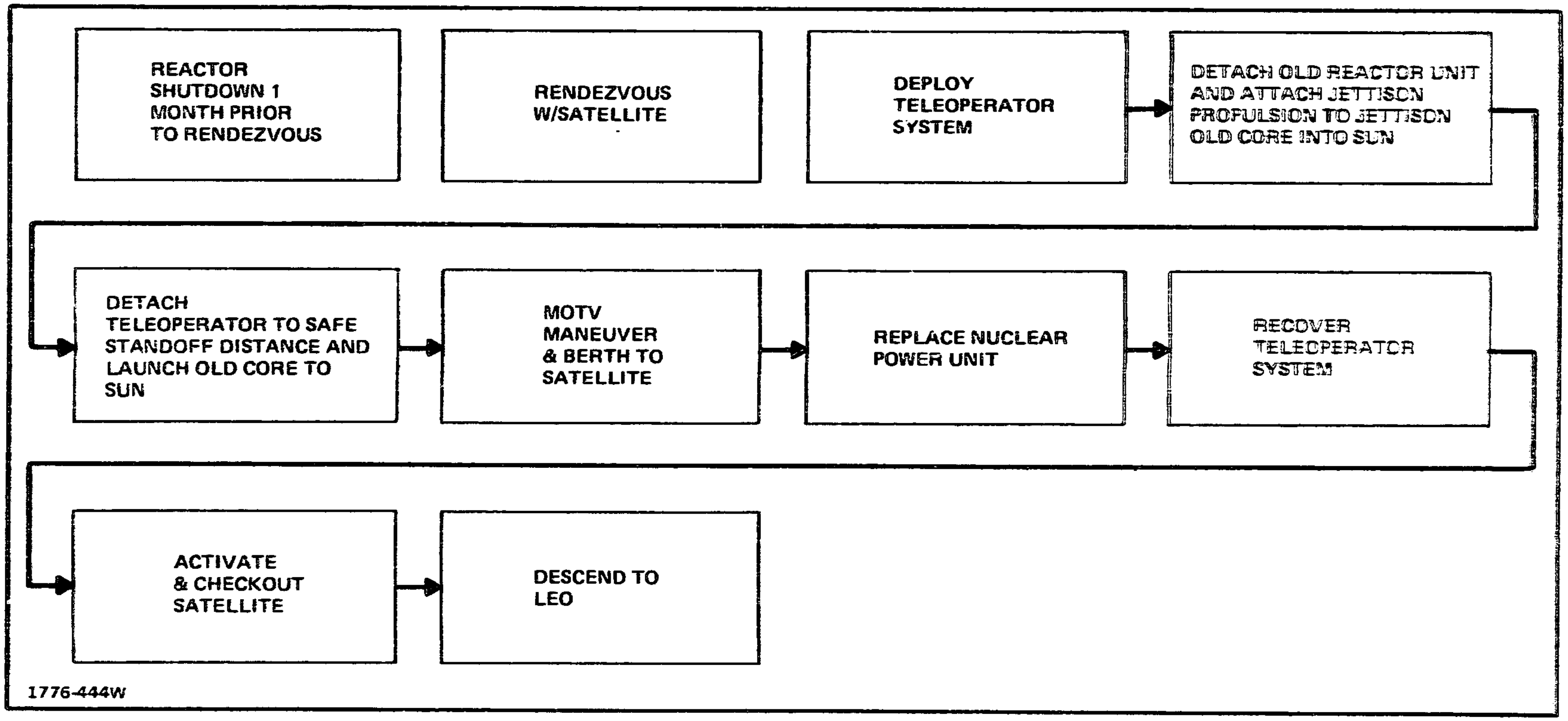


Fig. 4.4-4 S3(b) Replace Nuclear Power Core on GEO Satellite

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• DEPLOY TELEOPERATOR SYSTEM	(2:10)				
– UNSTOW & POSITION MANIPULATORS	:10	1 VA	1	OPERATE & MONITOR CONTROLS & DISPLAYS	PARALLEL ACTIVITIES
– RELEASE TELEOPERATOR	:20	1 VA	1		
– UNSTOW & POSITION TELEOPERATOR MANIPULATOR	:15	1 VA	1		
– C/O TELEOPERATOR SYSTEMS	:30	1 VA	1		
– ATTACH PROPULSION UNIT TO TELEOPERATOR		1 VA	1		
– MANEUVER TO INSPECT SATELLITE	:30	1 VA	2	OPERATE MOTV FLT. SYS. MONITOR DISPLAYS	
– MANEUVER TO BERTHING ATTITUDE	:10	1 VA	1		
– ACTIVATE & POSITION BERTHING PROBE	:05	1 VA	1		
– PERFORM CLOSING MANEUVER	:10	1 VA	1		
– CAPTURE & SECURE SATELLITE BERTHING		1 VA	1		
• REMOVE & DISPOSE OF POWER UNIT	(1:25)			OPERATE C & D'S FOR MANIPULATOR AND PAYLOAD SYSTEMS OPER. MANIP. END EFFECTOR	
– UNSTOW & POSITION PROPULSION UNIT	:20	1 VA	1		
– ATTACH PROPULSION UNIT	:25	1 VA	1		
– DISCONNECT & POSITION POWER PLANT	:35	1 VA	1		
• DISENGAGE TELEOPERATOR SYSTEM	(0:28)				
– RELEASE BERTHING PROBE	:03	1 VA	1	OPERATE GRAPPLER END EFFECTOR	
– MANEUVER TO STANDBY POSITION	:20	1 VA	1	OPERATE FLT. SYS.	
– LAUNCH REACTOR	:05	1 VA	1		
• MOTV MANEUVER & BERTH W/SATELLITE	(0:55)				
– PREPARE FOR FINAL APPROACH	:40	1 VA	1	OPERATE FLT. SYS.	
– MANEUVER TO BERTHING ATTITUDE					
– ACTIVATE & POSITION BERTHING DEVICE	:05	1 VA	1	OPERATE GRAPPLER CONTROLS	
– PERFORM CLOSING MANEUVER	:10	1 VA	1		
– CAPTURE & SECURE SATELLITE BERTHING					
• REPLACE POWER UNIT	(2:25)				
– POSITION MANIPULATORS	:10	1 VA	1	OPERATE C & D's FOR MANIPULATORS, PAYLOAD RACKS	
– C/O & UNSTOW NEW UNIT	:30	1 VA	1		
– POSITION UNIT	:25	1 VA	1		
– CONNECT UNIT	1:20	1 VA	1	OPERATE MANIP. END EFFECTORS	
• RECOVER TELEOPERATOR SYSTEM	(1:00)				
– MANEUVER TO STANDBY POSITION	:20	1 VA	1	OPERATE MOTV FLT. SYS.	
– DEACTIVATE TELEOPERATOR	:15	1 VA	1		VIA REMOTE MOTV COMMUNICATION
– RESTOW & SECURE TELEOPERATOR	:25	1 VA	1		
• ACTIVATE & CHECKOUT SATELLITE	(1:20)				
– ACTIVATE CORE AND CONTROL SYSTEM	:40	1 VA	1		VIA REMOTE MOTV COMMUNICATION
– SUPPORT SATELLITE SPACE – GROUND C/O	:40	1 VA	2	MONITOR ANTENNA SYSTEM	

1776-445W(1)

Fig. 4.4-5 S 3(b) – Functions, Time, & Tasks

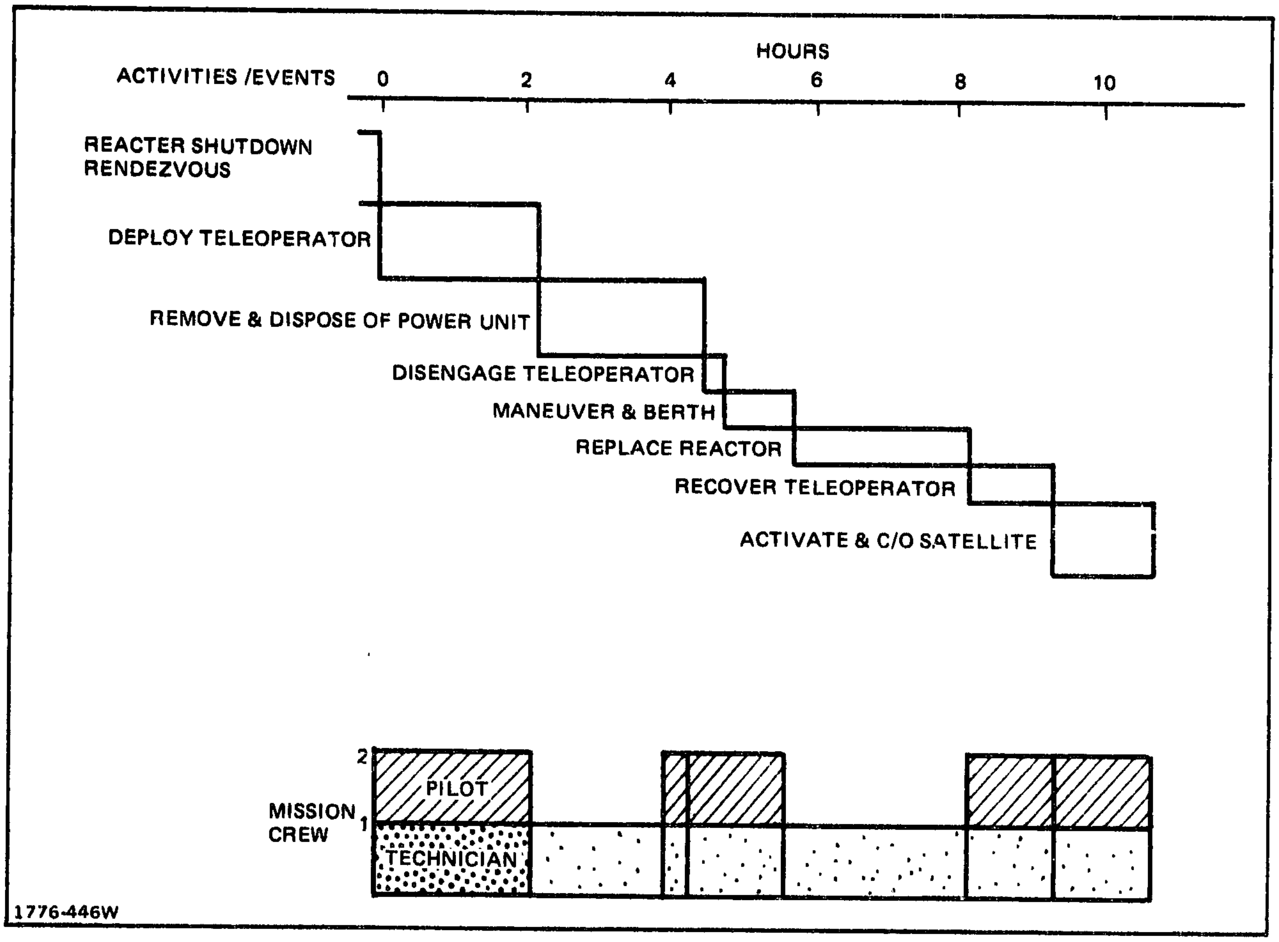


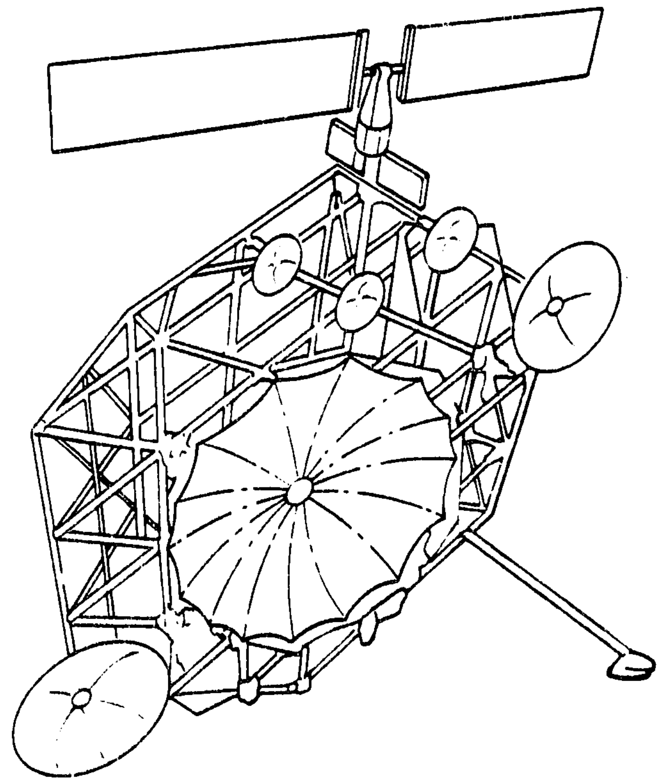
Fig. 4.4-6 S3(b) Timeline & Crew Requirements

4.5 GENERIC MISSION ER1 – EMERGENCY REPAIR OF A MULTIDISCIPLINED GEO PLATFORM

Mission Description: This mission is characterized by the unexpected nature of the failure incurred. It may be due to electronic component failure or mechanical failure. In either case it is seriousness enough to warrent immediate repair. Furthermore, the total extent of the damage is not entirely known. The MOTV is deployed with spare parts, repair tools, and on-board checkout equipment to determine the full extent of the failure and fix it. In addition, standard servicing of the satellite subsystems such as RCS fluid replenishment would also be done. The figure illustrates this type of mission.

Characteristics:

Weight	25,000 kg
Size	80 m
Power	40 kW
Orbit	GEO
Timeframe	1990
Life/Servicing Period	30/3 yr



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Rationale for MOTV Use:

- Full nature of the failure cannot be determined remotely, and requires man on-site for repair and checkout
- Man's visibility and on-site decision making capability are not easily replaced by remote controlled, automated systems.

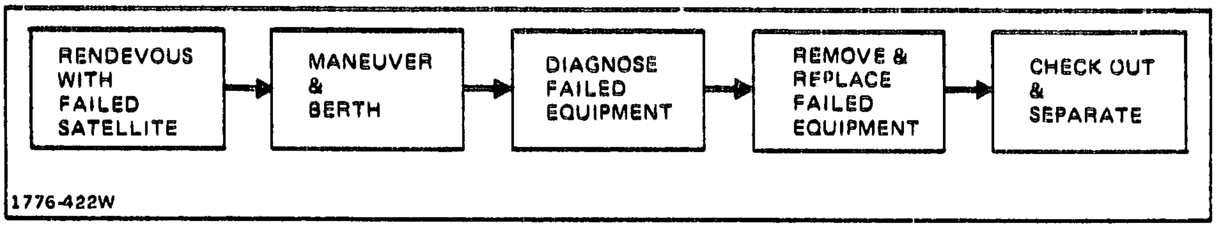

Fig. 4.5-1 ER1 – Emergency Repair (GEO)

ACTIVITY/FUNCTION	TIME HR:MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MANEUVER & BERTH	(1:00)	IVA			
– PREPARE FOR FINAL APPROACH					
– MANEUVER TO INSPECT SATELLITE	:45				SPACE TUG DATA
– MANEUVER TO BERTHING ATTITUDE					
– ACTIVATE & POSITION BERTHING SYS	:05				
– PERFORM CLOSING MANEUVER	:10				
– CAPTURE SATELLITE & SECURE BERTHING					
• DIAGNOSE FAILED EQUIPMENT	(2:45)	IVA			
– ACTIVATE MANIPULATOR SYS	:10				
– SHUTDOW ELECT. SYS AS NEEDED	:05				
– CHECK OUT SATELLITE SUBSYS	:30				
– DETAIL CHECKOUT & FAULT ISOLATION	2:00				
– SUPPORT SPACE–GRND SYS TEST AS NEEDED					
• REMOVE & REPLACE FAILED EQUIP.	(10:45)	IVA			
– REMOVE 30 m ANTENNA	:45				
o FOLD 30 m ANTENNA	–				
o REMOVE & STOW ANTENNA	–				
– REPAIR BEAM	:10				
o REMOVE & STOW BEAM SEGMENT	–				
o REPLACE & LOCK SEGMENT	–				
REPLACE ANTENNA	1:05				
o MOUNT NEW ANTENNA	–				
o DEPLOY ANTENNA	–				
– SUPPORT SPACE-GROUND CHECKOUT	:20				
– SERVICE RCS UNITS (2)	3:00				
o REMOVE & STOW PROP. TANK	–				
o UNSTOW, INSTALL & C/O PROP. TANK	–				
– REBERTH	:45				
o STOW MANIPULATORS	–				
o RELEASE, MANEUVER & REBERTH	–				
o REPOSITION MANIPULATOR	–				
– REPAIR 10 m ANTENNA SYS	1:20				
o REMOVE & STOW COMPONENT	–				
o REPLACE COMPONENT	–				
– SUPPORT SPACE-GROUND C/O	:20				
– SERVICE RCS UNITS (2) (AS ABOVE)	3:00				
• SEPARATE & COMPLETE C/O	(1:00)	IVA			
– SAFE & STOW MANIPULATOR	:15				
– SUPPORT SPACE-GROUND C/O	:35				
– MANEUVER TO VERIFY SAT. CONF	:10				
TOTAL	15:30				

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Fig. 4.5-2 ER1,–Functions, Time & Tasks

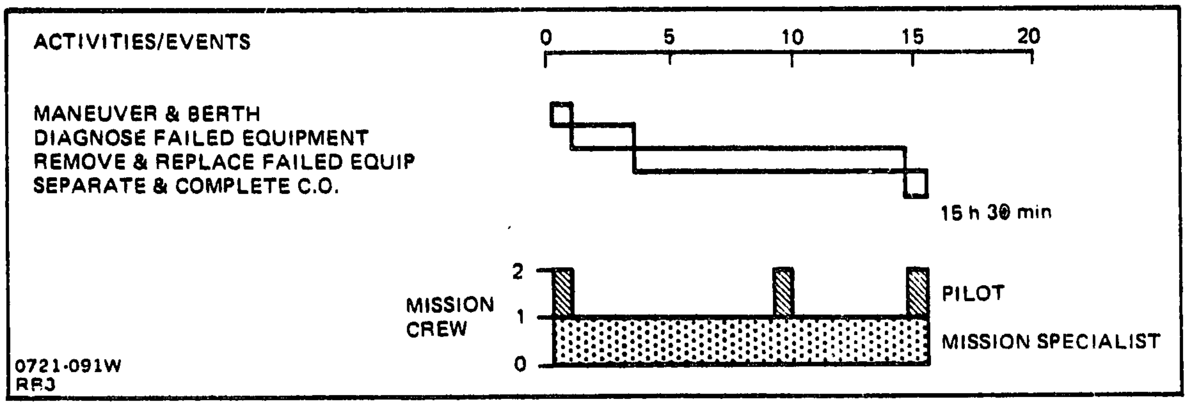


Fig. 4.5-3 ER1-Timeline & Crew Requirements

4.6 GENERIC MISSION ER2 - EMERGENCY REPAIR OF A SURVEILLANCE SATELLITE IN A 12 HR/63° INCLINED ORBIT

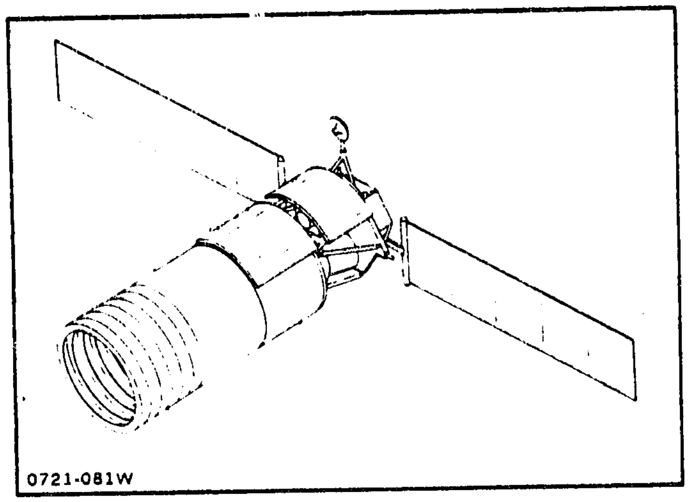
Mission Description: This mission is characterized in the same manner as Generic Mission ER1. In this case, however, the satellite and its orbit are very different. The satellite's electronics, optics or mechanical system may have failed. The MOTV is deployed to rendezvous and dock with the disabled satellite even assuming it has lost its stabilization and control system and is uncontrollably tumbling. The MOTV would stabilize the satellite and perform repairs as required. In addition, standard servicing of the satellite subsystem such as RCS fluid replenishment would also be done. The figure illustrates this mission.

Characteristics:

Weight	4100 kg
Size	NA
Power	4.5 kW
Orbit	12 hr/63°
Timeframe	1990s
Life/Servicing Period	20/3 yr

Rationale for MOTV Use:

- Same as Generic Mission ER1



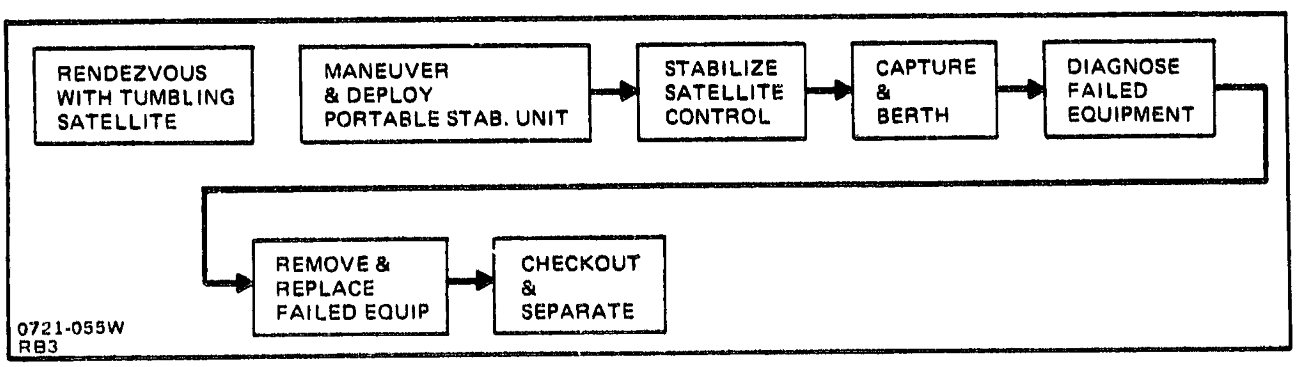


Fig. 4.6-1 ER2-Emergency Repair (HEO)

ACTIVITY/FUNCTION	TIME HR:MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MANEUVER & DEPLOY PSU	(1:00)	IVA			
– PREPARE FOR FINAL APPROACH					
– MANEUVER TO INSPECT SATELLITE	:40				
– MANEUVER TO PSU DEPLOYMENT ATTITUDE					
– C/O, ACTIVATE & DEPLOY PSU	:20				
• STABILIZE SATELLITE	(:30)	IVA			
– MANEUVER PSU TO SATELLITE	:10				
MANEUVER PSU TO CAPTURE SATELLITE	:10				
– STABILIZE SAT. VIA PSU	:10				
• CAPTURE & BERTH	(:45)	IVA			
– MANEUVER TO INSPECT SATELLITE	:20				
– MANEUVER TO BERTHING ATTITUDE	:10				
– ACTIVATE & POSITION BERTH. SYS.	:05				
– PERFORM CLOSING MANEUVER					
– CAPTURE & SECURE SAT. BERTH.	:10				
• DIAGNOSE FAILED EQUIPMENT	(2:45)	IVA			
– ACTIVATE MANIPULATOR SYS	:10				
– SHUTDOWN ELECT. SYSTEM AS NEEDED	: 5				
– CHECK OUT SATELLITE SUBSYS.	:30				
– DETAIL CHECKOUT & FAULT ISOLATION					
– SUPPORT SPACE-GRND SYS TEST AS NEEDED	2:00				
TOTAL	5:00				
• REMOVE & REPLACE FAILED EQUIPMENT	(6:40)	IVA			
– REMOVE & STOW SIGNAL PROCESSOR	:40				
– REPLACE SIGNAL PROCESSOR	:50				
– REMOVE & STOW PAYLOAD CONTROLLER	:30				
– REPLACE PAYLOAD CONTROLLER	:40				
– REPLENISH CYRO FLUID IN COOLER	:50				
– C/O COOLER	:10				
– SERVICE RCS UNITS (2)	3:00				
REMOVE & STOW RCS	–				
UNSTOW, INSTALL & C/O RCS	–				
• CHECK OUT & SEPARATE	(1:10)	IVA			
– SUPPORT SPACE-GROUND CHECKOUT	:35				
– REMOVE & STOW PSU	:10				
– SAFE & STOW MANIPULATORS	:15				
– MANEUVER TO VERIFY SAT. CONFIG	:10				
TOTAL	12:50				

0721-069W

RB3

Fig. 4.6-2 ER2-Functions, Time & Task

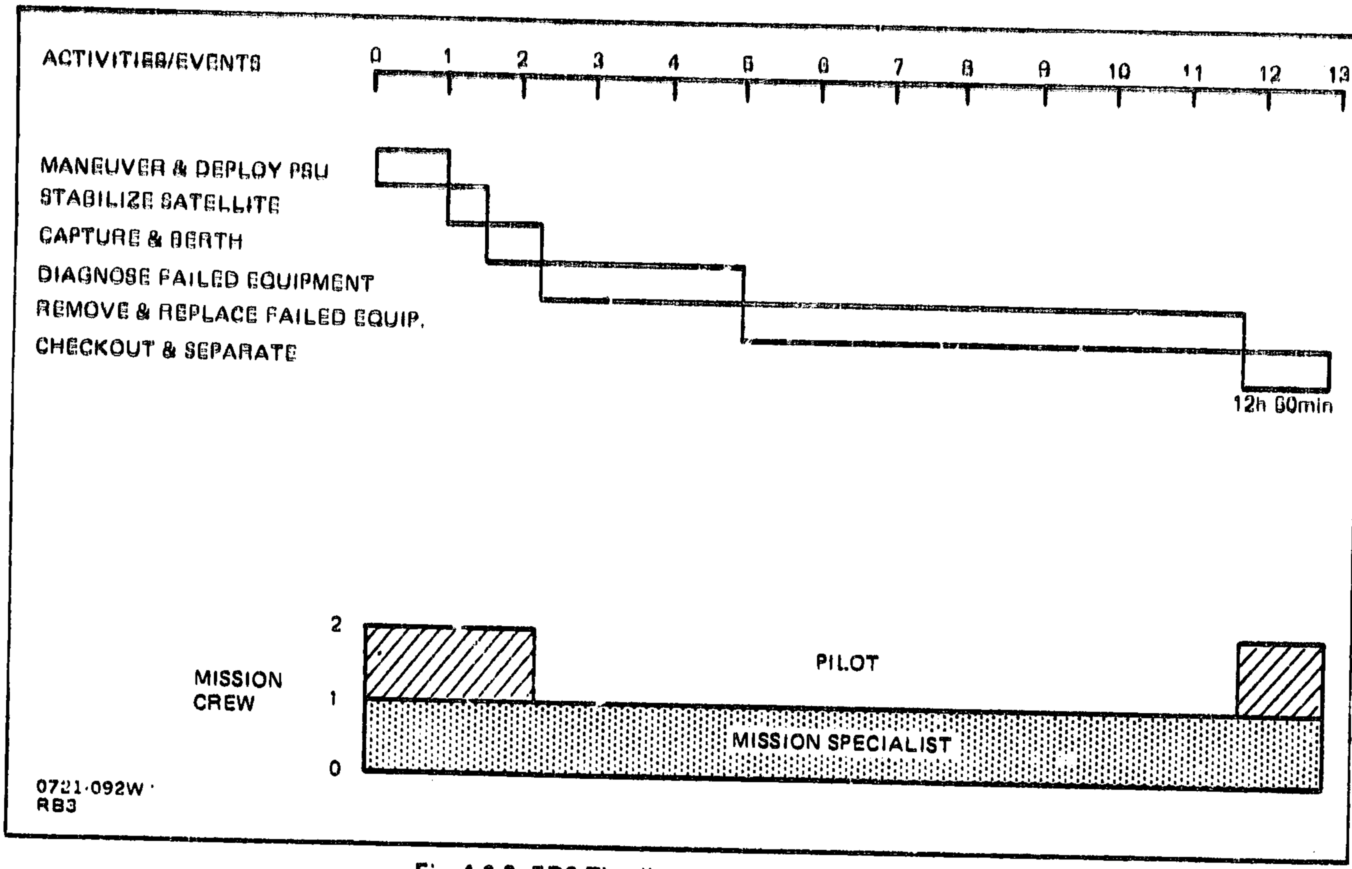


Fig. 4.6-3 ER2-Timeline & Crew Requirements

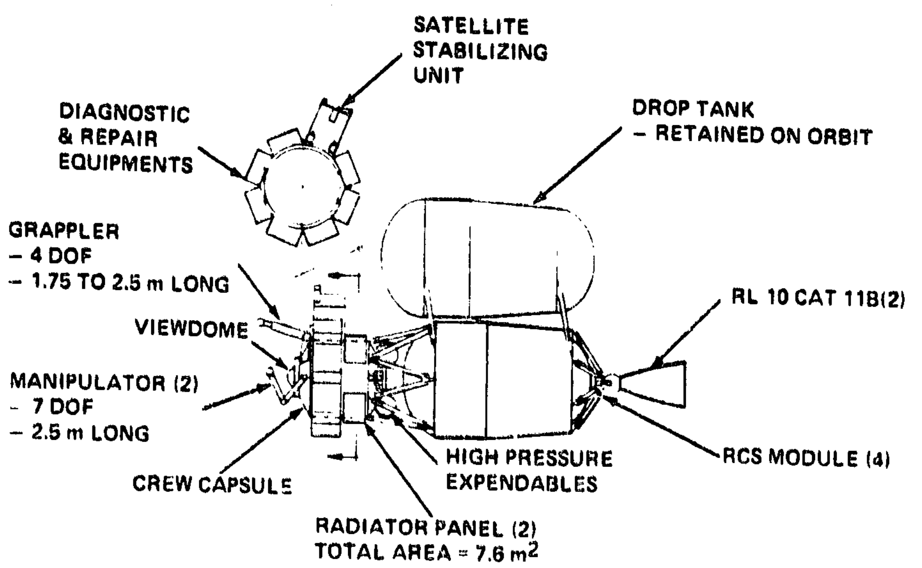


Fig. 4.6-4 MOTV Configuration For Mission ER2

	CREW CAPSULE	PROP'LS'N CORE	DROP TANKS (1)	MISSION EQUIP'T GENERAL PURPOSE	MISSION EQUIP'T DEDICATED
DRY WEIGHT	3541	3169	1476	669	1012
CREW/CONSUMABLES	271	130			
RESERVES/RESIDS		296	236		
BURNOUT WEIGHT	3812	3595	1710	669	1012
MAIN PROP – (CAPACITY)		(17,500)	(27,270)		
– LOADING		17,369	18,063		
ACPS PROP		567			
MISC		145			77
MOTV WEIGHT	3812	21,676	19,773	669	1089
TOTAL MOTV WEIGHT	47,019				

1776-421W

Fig. 4.6-5 ER2 Summary Wt Statement, kg

CREW CAPSULE		WEIGHT, kg
STRUCTURE		1515
THERMAL PROT		48
EPS		25
AVIONICS		149
ECLS		493
CREW ACCOM		597
PROPULSION		6
RECOVERY		–
CONTINGENCY	(25%)	708
TOTAL DRY WEIGHT		3541
CREW	(2)	163
CONSUMABLES	(3.4 DAYS)	108
BURNOUT WEIGHT		3812

NOTES
- MANIPULATORS, ETC., CHARGED TO GEN PURPOSE MISSION EQUIP.
- EPS SUBSYS IS POWER DISTR ONLY – REMAINDER OF SUBSYS IN PROP. CORE

1776-423W

Fig. 4.6-6 ER2 Wt Statement (Crew Capsule)

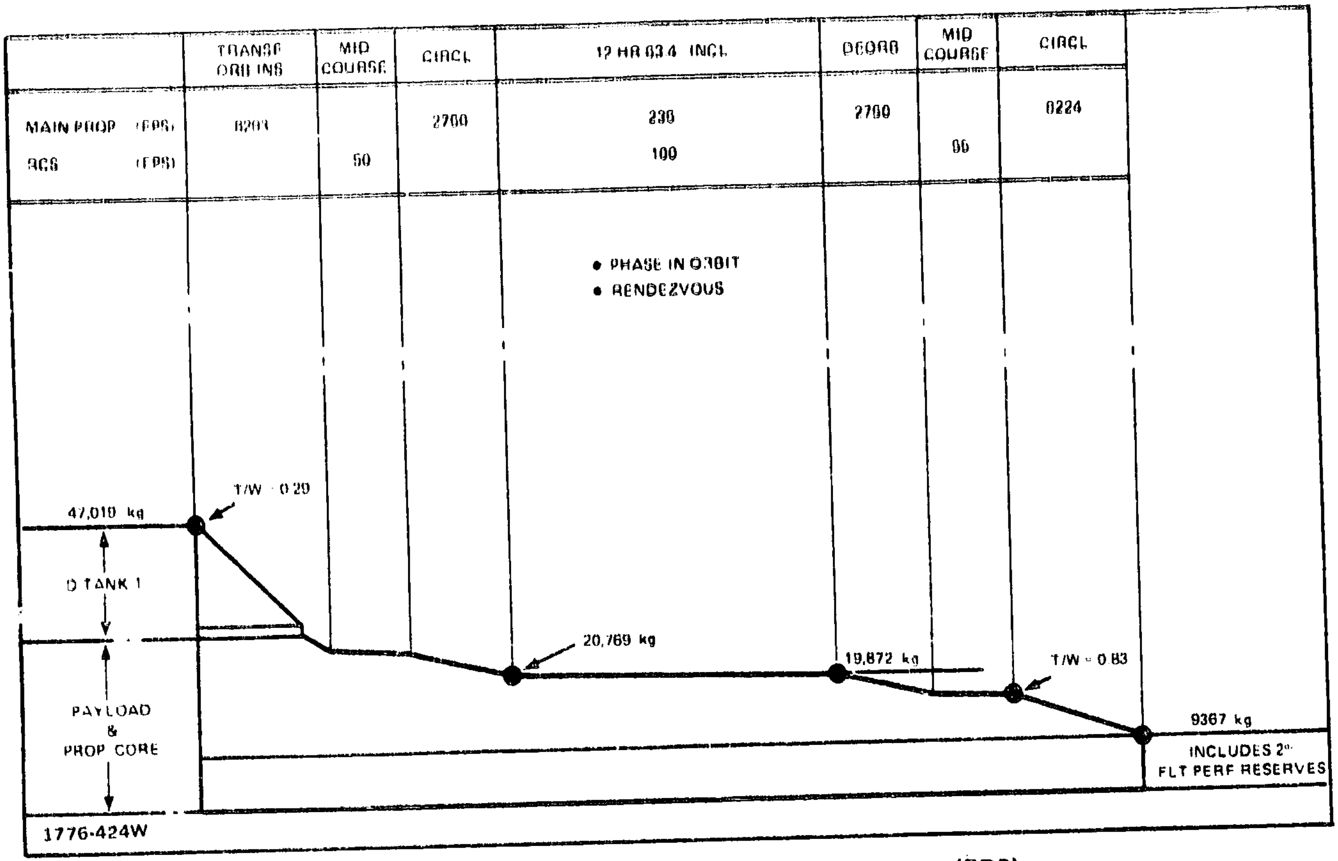


Fig. 4.6-7 Performance Data – Emergency Repair Mission (ER2)

4.7 GENERIC MISSION R1 - RETRIEVAL OF A SURVEILLANCE SATELLITE FROM 12 HR/63° INCLINED ORBIT

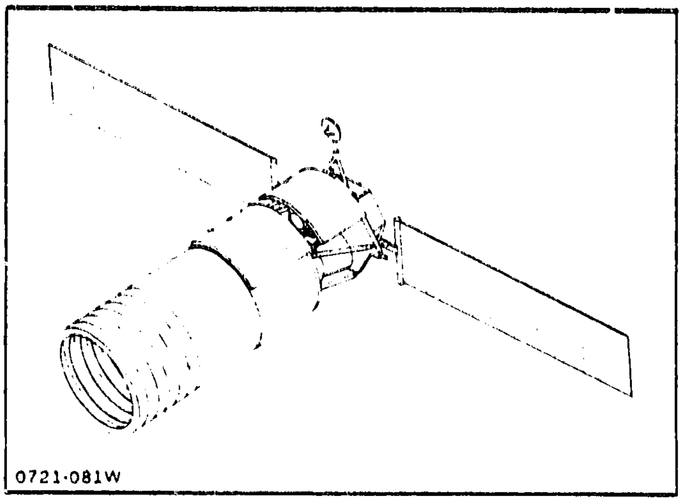
Mission Description: The same satellite described in Generic Mission ER2 is assumed disabled and must be retrieved. As before, the satellite can be tumbling and must be stabilized before it can be retrieved. The MOTV is deployed to the proper orbit, locates and rendezvous with the satellite, and performs the appropriate stabilization functions. Once this is accomplished the MOTV grapples the satellite and prepares it for the return trip to LEO, and subsequent trip back to earth in the Shuttle. The figure depicts this type of operation.

Characteristics:

Weight. . . . . 4100 kg
Size. . . . . NA
Power. . . . . 4.5 kW
Orbit . . . . 12 hr/63°
Timeframe 1990s
Life/Servicing Period . . 20/3 yr

Rationale for MOTV Use:

- Same as Generic Mission ER2



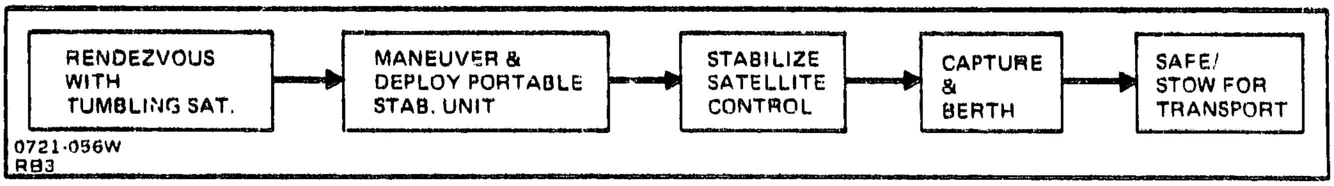


Fig. 4.7.1 R1 – Retrieval of Failed Satellite

ACTIVITY/FUNCTION	TIME HR. MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MANEUVER & DEPLOY PSU	(1.00)	IVA			
- PREPARE FOR FINAL APPROACH - MANEUVER TO INSPECT SATELLITE	.40				SPACE TUG
MANEUVER TO PSU DEPLOY. ATTITUDE - C/O ACTIVATE & DEPLOY PSU	.20				
• STABILIZE SATELLITE CONT	(:30)	IVA			SAT. RETRIEVAL STUDY
– MANEUVER PSU TO SATELLITE	:10				
– MANEUVER PSU TO CAPTURE SATELLITE	:10				
- STABILIZE SAT. VIA PSU	10				
• CAPTURE & BERTH	(:45)	IVA			
- MANEUVER TO INSPECT SATELLITE	.20				
- MANEUVER TO BERTHING ATTITUDE	10				
- ACTIVATE & POSITION BERTHING SYS.	5				
- PERFORM CLOSING MANEUVER CAPTURE & SECURE SAT. BERTHING	.10				
• SAFE & STOW FOR TRANSPORT	(1.45)	IVA			
ATTACH ELECTRICAL INTERFACE SHUTDOWN EXCESS SAT. ELECT. SYS	1:00				
VENT PROPELLANTS/FLUIDS AS NEEDED	:20				
- REMOVE, SAFE OR STOW APPENDAGES	:25				
TOTAL	4:00				

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RB3

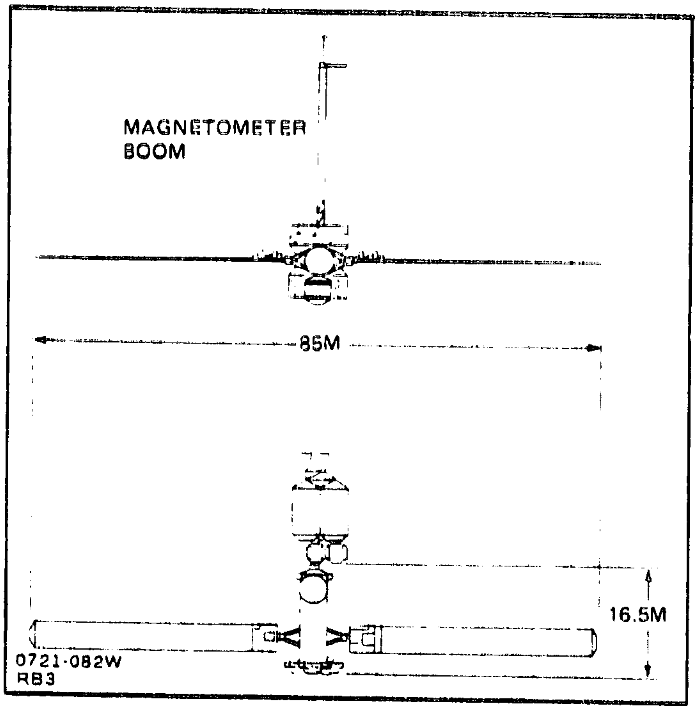
Fig. 4.7-2 R1-Functions, Time, & Tasks

4.8 GENERIC MISSION OP1 - OPERATION OF A LARGE SPACE SYSTEM, STO GEO PLATFORM

Mission Description: A large Solar-Terrestial Observatory (STO) of the type shown in the figure is deployed in GEO. It operates automatically most of the time telemetering its findings back to earth. Once a year, however, for a period of two weeks it is manned. During this time, in-situ experiments are conducted, experiment packages are changed out, instruments are recalibrated, critical fluids are replenished, and other servicing or maintenance, as needed, is performed.

Characteristics:

Weight	26,000 kg
Size	NA
Power	50 kW
Orbit	GEO
Timeframe	1991
Life/Servicing Period	20/1 yr



Rationale for MOTV Use:

- Man is needed to conduct in-situ experiments which are sometimes dependent on targets of opportunity
- Changeout of experiments, calibration of instruments, and general service/maintenance is simpler with man.

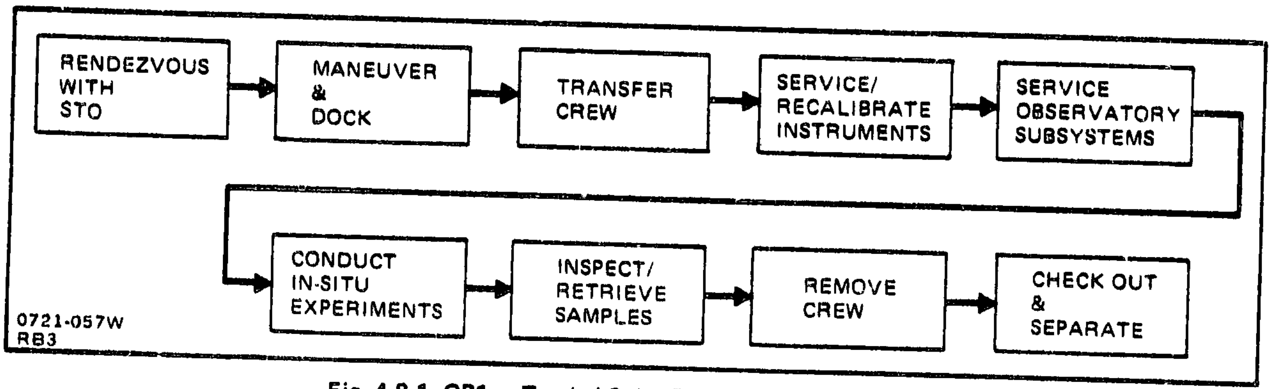


Fig. 4.8-1 OP1 – Tended Solar Terrestrial Observatory

ACTIVITY/FUNCTION	TIME HR:MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MANEUVER & DOCK	(1:00)	IVA			
– PREPARE FOR FINAL APPROACH – MANEUVER TO DOCKING ATTITUDE	:30				
– ACTIVATE & POSITION DOCKING SYS.	:10				
– PERFORM CLOSING MANEUVER – CAPTURE STO & SECURE DOCKING	:20				
• TRANSFER CREW & EQUIPMENT	(1:30)	IVA			
– PRESSURIZE & TEST ATMOSPHERE	:40				
– OPEN HATCH	:10				
– TRANSFER EQUIPMENT & CREW	:40				
• SERVICE/RECALIBRATE INSTRUMENTS	TBD	IVA			
• SERVICE OBSERVATORY SUBSYSTEMS	(:45)	IVA			
– REMOVE & STOW RCS PROPELLANT TANKS	:20				
– UNSTOW, INSTALL & C/O REPLACEMENT TANKS	:25				
– REMOVE & STOW CRYOGENIC TANKS	:20				
– UNSTOW, INSTALL & C/O REPLACEMENT TANKS	:25				
• CONDUCT IN-SITU EXPERIMENTS	TBD	VA			
• INSPECT/RETRIEVE SAMPLES	(4:00)	IVA			
– INSPECT SAMPLE TRAYS	:20				
– RELEASE, TRANSLATE & STOW TRAY	:25				
– UNSTOW & MOVE NEW TRAY TO STO	:10				
– POSITION & INSTALL NEW TRAY	:25				
– REPEAT TWICE MORE @ 1:20	2:40				
• REMOVE CREW	(:50)	IVA			
– STOW EQUIPMENT	:30				
– TRANSFER CREW	:10				
– CLOSE HATCH	:10				
• CHECK OUT & SEPARATE	(1:00)	IVA			
– RELEASE DOCKING DEVICE	:15				
– MANEUVER TO VERIFY STO CONFIG	:10				
– SUPPORT SPACE/GROUND CHECKOUT	:35				
TOTAL	9:05				

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RB3

Fig. 4.8-2 OP1-Functions, Time & Tasks

4.9 GENERIC MISSION P1 - PASSENGER TRANSPORT 3-MAN CREW ROTATION/ RESUPPLY TO GEO

Mission Description: A 3-man crew is transported with supplies to a GEO Space Construction Base (SCB). The SCB assembles PSP's, SPDA's, Navigation & Surveillance antenna and operates an STO. It is permanently manned and requires quarterly visits. The functions of the MOTV in this scenario are: crew rotation, SCB resupply, transfer of special tools and equipment and return of high priority cargo, wastes and crew. The overall MOTV stay time in GEO is short, at most a couple of days.

Characteristics:

Weight . . . .
Size . . . .
Power . . . .
Orbit. . . . . GEO
Timeframe . . . . Early 90s
Life/Servicing Period . . 20/4X per yr

Rationale for MOTV Use:

- Required for Crew Rotation.

RESUPPLY ITEM	LEO* 10 MEN	P1 GEO 3 MEN 90 DAYS		P2 GEO 10 MEN 90 DAYS		P3 GEO 30 MEN 90 DAYS		P4 GEO 8 MEN 90 DAYS	
	WGT. kg	DEPLOY, kg	RETURN kg	DEPLOY, kg	RETURN, kg	DEPLOY, kg	RETURN, kg	DEPLOY, kg	RETURN, kg
– OXYGEN	–	–	–	–	–	–	–	–	–
– NITROGEN (LEAKAGE MAKEUP)	1868 1	561	281	1868	934	5604	2802	121	561
– POTABLE WATER	190 2	57	6	190	19	570	57	14	11
– LiOH	–	–	–	–	–	–	–	–	–
– FOOD	2250 3	675	8	2250	270	6750	810	1386	18
– CLOTHING	225	68	68	225	225	675	675	135	136
– FILTER MATERIAL	–	72	72	240	240	720	720	144	144
	4533	1433	435	4773	1688	14319	5084	2864	887
– RCS	1208 4	250	42	833	139	2500	420	500	83
TOTAL RESUPPLIES	5741	1683	471	5606	1827	16,819	5484	3364	950

NOTES:
1 INCLUDES 1 kg N_2 TANK/kg N_2
2 INCLUDES 0.1 kg H_2O TANK/kg H_2O
3 FOOD RESIDUE = 0.3 kg/MEN-DAY
4 RCS TANKAGE = 0.2 kg TANK/kg PROP.
*REF: SSAS FINAL REPORT, PART 3, 17 JUNE 1977 PG 4-41

0721-122W
RB3

Fig. 4.9-1 Passenger Transport Missions P1-P4 Consumables/Expendables for 90-Day Spacebases

4.10 GENERIC MISSION P2 - PASSENGER TRANSPORT 8-MAN CREW ROTATION/ RESUPPLY TO GEO

Mission Description: This mission is similar to Generic Mission P1 except the crew size and consequently the resupplies are much larger. An 8-man Space Construction Base is assumed in GEO performing essentially the same functions as previously described. The structures being assembled are larger and more complex therefore requiring more construction workers.

Characteristics:

Weight . . . .
Size . . . .
Power . . . .
Orbit . . . . GEO
Timeframe . . . . Mid 90s
Life/Servicing Period . . 20/4X per year

Rationale for MOTV Use:

- Required for Crew Rotation

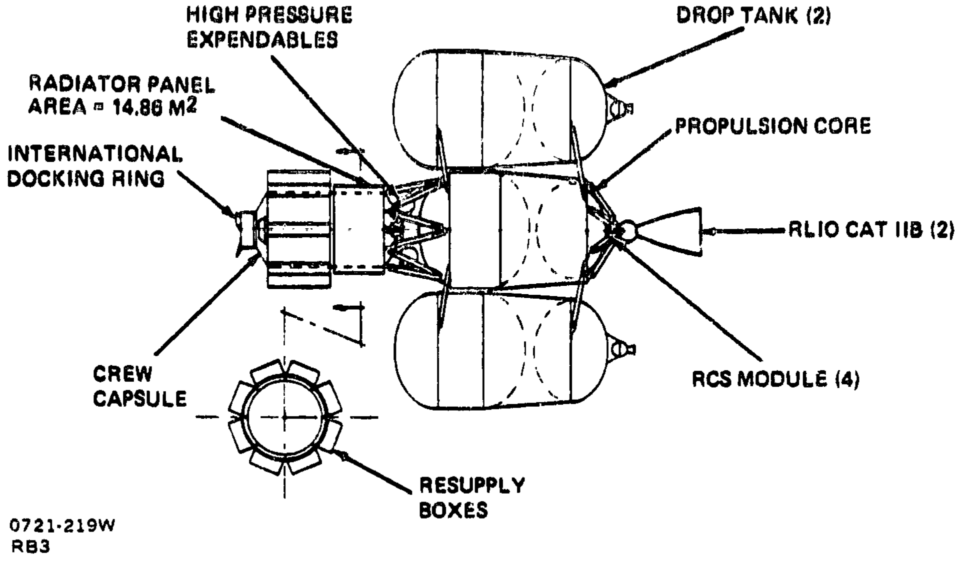


Fig. 4.10-1 MOTV Configuration for Mission P2

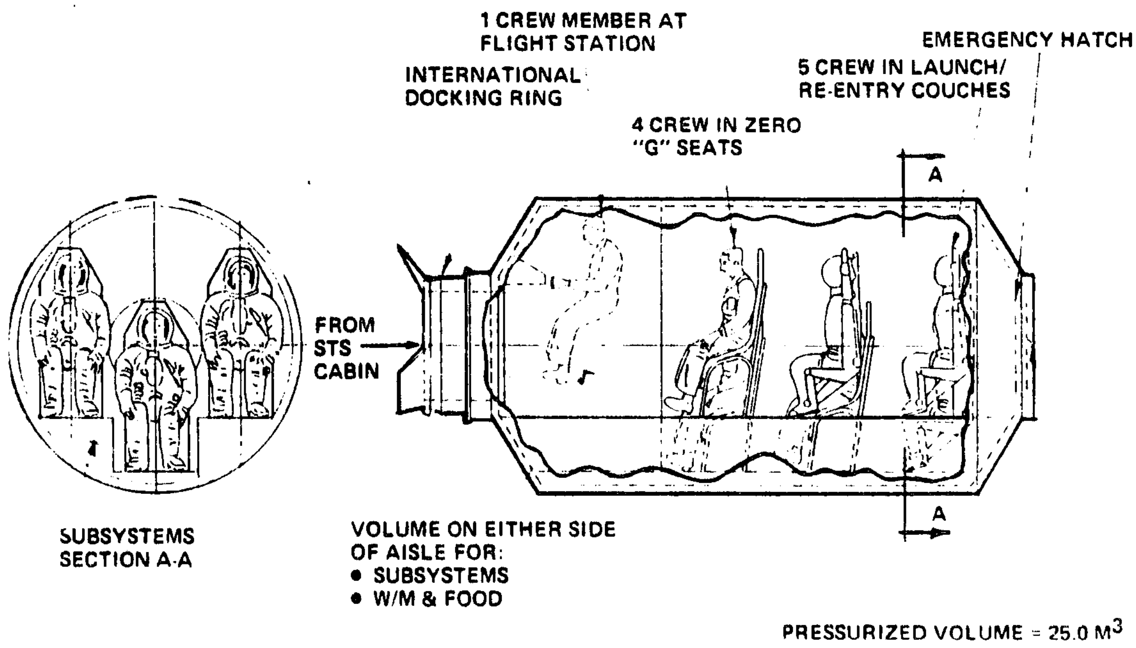


Fig. 4.10-2 APOTV Crew Module (Large) – 10 Man

	CREW CAPSULE	PROP'LS'N CORE	DROP TANKS (3)	MISSION EQUIP'T GENERAL PURPOSE	MISSION EQUIP'T DEDICATED
DRY WEIGHT	3992	3330	4425	763	1463
CREW/CONSUMABLES RESERVES/RESIDS	988	51 296	705		
BURNOUT WEIGHT	4980	3677	5130	763	1463
MAIN PROP – (CAPACITY) – LOADING ACPS PROP MISC		(17,500) 12,294 1011 145	(81,810) 65,197		3022
MOTV WEIGHT	4980	17,127	70,327	763	4485
TOTAL MOTV WEIGHT	97,682				

1776-425W

Fig. 4.10-3 P2 Summary Wt Statement, kg

CREW CAPSULE		WEIGHT, kg
STRUCTURE		1465
THERMAL PROT		48
EPS		25
AVIONICS		149
ECLS		782
CREW ACCOM		719
PROPULSION		6
RECOVERY		–
CONTINGENCY	(25%)	798
TOTAL DRY WEIGHT		3992
CREW	(8)	653
CONSUMABLES	(4 DAYS)	335
BURNOUT WEIGHT		4980

NOTES
- MANIPULATORS, ETC., CHARGED TO GEN PURPOSE MISSION EQUIP.
- EPS SUBSYS IS POWER DISTR ONLY – REMAINDER OF SUBSYS IN PROP. CORE

1776-426W

Fig. 4.10-4 P2 Wt Statement (Crew Capsule)

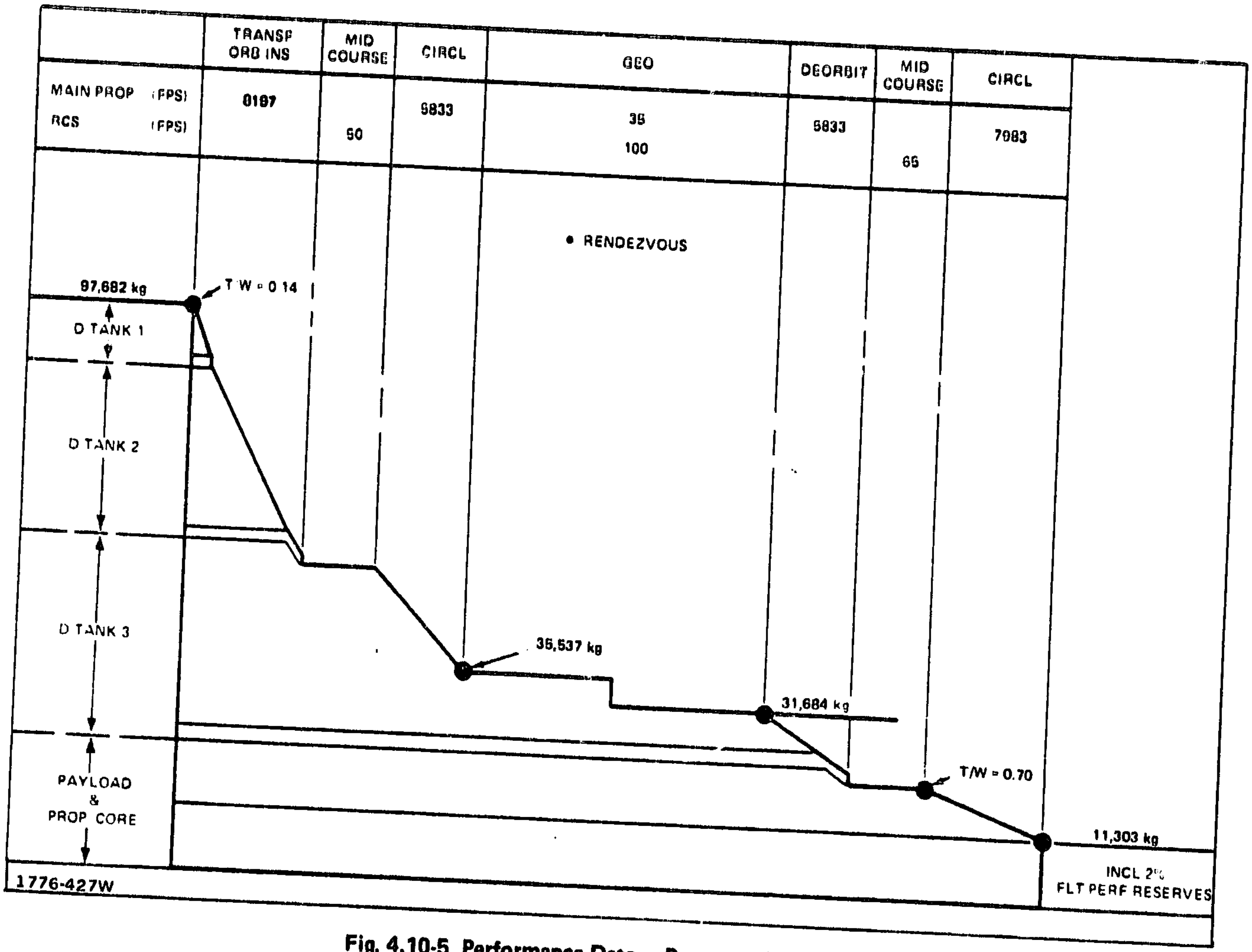


Fig. 4.10-5 Performance Data – Passenger Transport Mission (P2)

4.11 GENERIC MISSION P3 - PASSENGER TRANSPORT 30 MAN CREW ROTATION/ RESUPPLY TO GEO

Mission Description: This mission is characterized in the same manner as the previous two generic missions except the size of the construction base now dictates a 30-man crew size for its operation. This Advanced SCB is envisioned as the pilot facility needed for SPS construction.

Characteristics:

Weight. . . . .
Size . . . .
Power . . . .
Orbit . . . . GEO
Timeframe . . . . Mid-Late 90s
Life/Servicing Period . 20/4X per yr

Rationale for MOTV Use:

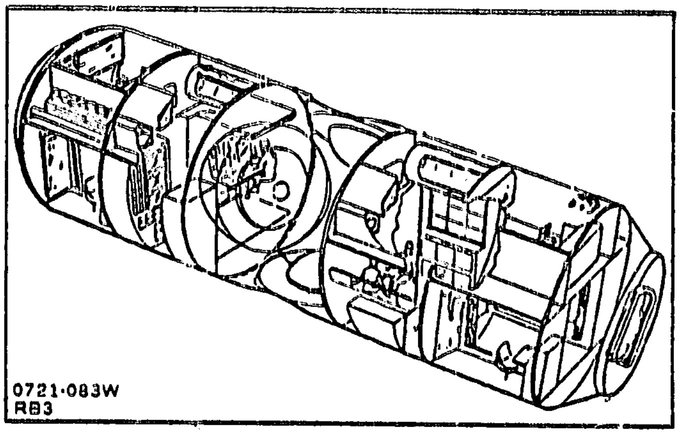
- Required for Passenger Transport to GEO.

4.12 GENERIC MISSION P4 - PASSENGER TRANSPORT SIX-MAN CREW ROTATION/ RESUPPLY TO A DEEP SPACE COMMAND POST (DSCP)

Mission Description: A DSCP as illustrated in the figure is located 400,000 n mi from earth. The MOTV visits this facility twice a year bringing with it provisions and crew for a three-month tour of duty. The MOTV stays long enough to transfer crew, supplies and provisions then leaves. The supplies include parts, special tools, and c/o equipment if needed, etc., to service the command post.

Characteristics:

Weight. . . . . 45,000 kg
Size . . . .
Power . . . .
Orbit . . . . 400,000 n mi
Timeframe . . . . Late 90s
Life/Servicing Period . . . 30/2X per yr



Rationale for MOTV Use:

- Required for Crew Transfer

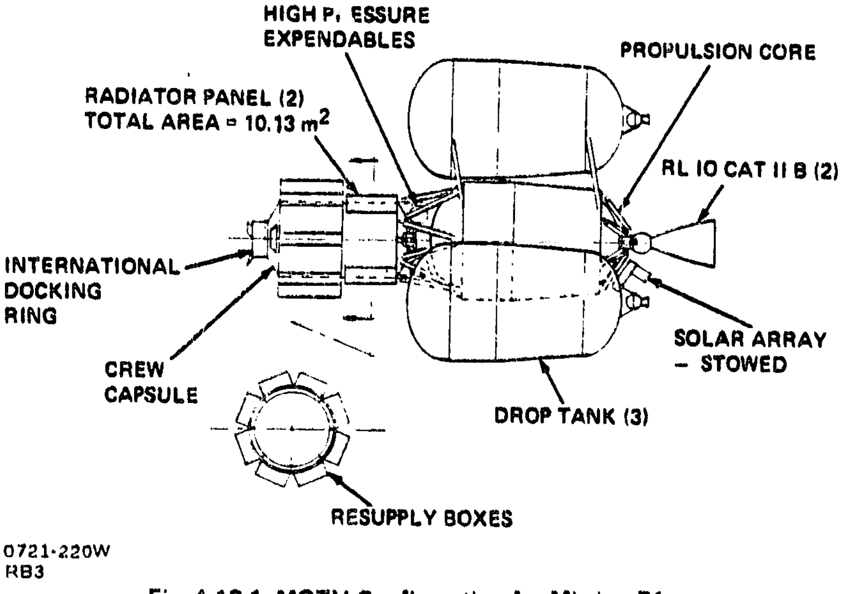


Fig. 4.12-1 MOTV Configuration for Mission P4

	CREW CAPSULE	PROP'L'N CORE	DROP TANKS (3)	MISSION EQUIP'T GENERAL PURPOSE	MISSION EQUIP'T DEDICATED
DRY WEIGHT	6469	3329	4426	763	950
CREW/CONSUMABLES	1366	61			
RESERVES/RESIDS		280	706		
BURNOUT WEIGHT	7835	3670	5130	763	950
MAIN PROP – (CAPACITY)		(17,500)	(81,810)		
– LOADING		9967	68,736		
ACPS PROP		1167			
MISC		146			2414
MOTV WEIGHT	7835	14,946	73,866	763	3364
TOTAL MOTV WEIGHT	100,772				

1776-428W

Fig. 4.12-2 P4 Summary Wt Statement, kg

CREW CAPSULE		WEIGHT, kg
STRUCTURE		1465
THERMAL PROT & PROTON SHELTER		1417
EPS		25
AVIONICS		149
ECLS		747
CREW ACCOM		1366
PROPULSION		6
RECOVERY		–
CONTINGENCY	(25%)	1294
TOTAL DRY WEIGHT		6469
CREW	(6)	490
CONSUMABLES	(30 DAYS)	876
BURNOUT WEIGHT		7835

NOTES
- MANIPULATORS, ETC., CHARGED TO GEN PURPOSE MISSION EQUIP.
- EPS SUBSYS IS POWER DISTR ONLY – REMAINDER OF SUBSYS IN PROP. CORE

1776-429W

Fig. 4.12-3 P4 Wt Statement (Crew Capsule)

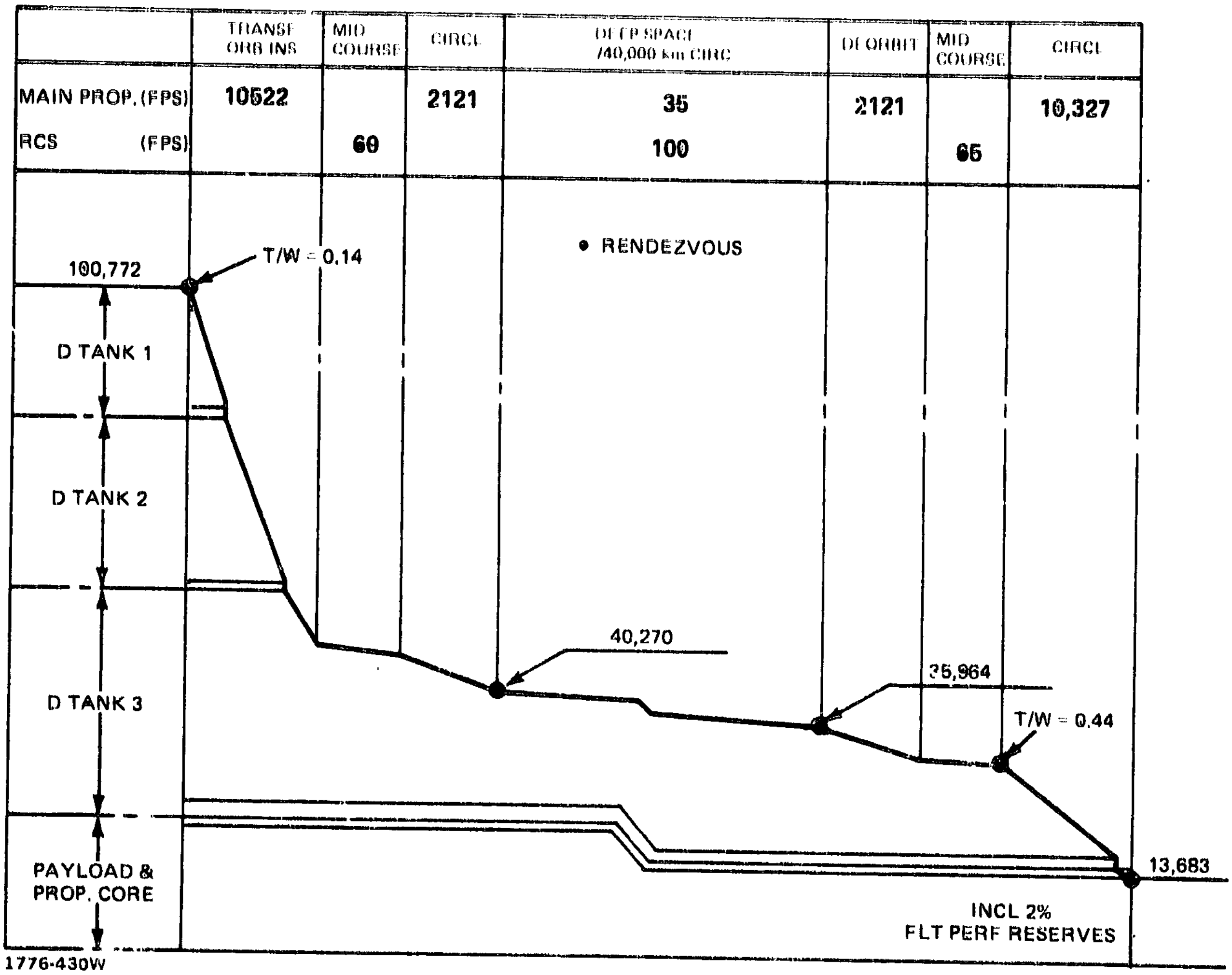


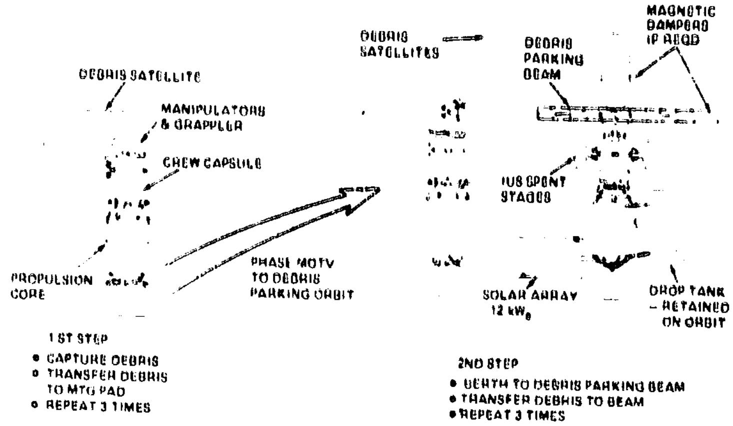
Fig. 4.12-4 Performance Data – Passenger Transport Mission (P4)

4.13 GENERIC MISSION DR1 - DEBRIS REMOVAL FROM GEO

Mission Description: The MOTV is dispatched to GEO to sweep debris from a 45° sector of the orbit. Three stops are made in orbit; the first two to pick up dead but stable communications satellites (Intelsat type) each separated $22\frac{1}{2}$° in longitude, and the third to remove spent propellant tanks, propulsion, stages, etc., which were previously deposited in a GEO space junkyard. After collecting each of these payloads the MOTV propels them to a higher orbit where their presence would not interfere with future space endeavors. The orbit of this newjunk yard is between 1000 and 5000 n mi above GEO. After depositing its payload the MOTV deorbits and returns to earth. The figure illustrates this mission scenario.

Characteristics:

Weight	5500 kg
Size	NA
Power	NA
Orbit	GEO
Timeframe	1990s
Life/Servicing Period	NA



Rationale for MOTV Use:

- The MOTV may perform this mission as part of a servicing or repair mission, or independently depending on the number and physical characteristics of the satellites being transferred
- This mission is much more complex if attempted unmanned and is beyond the performance capabilities of future teleoperator systems or cargo OTVs.

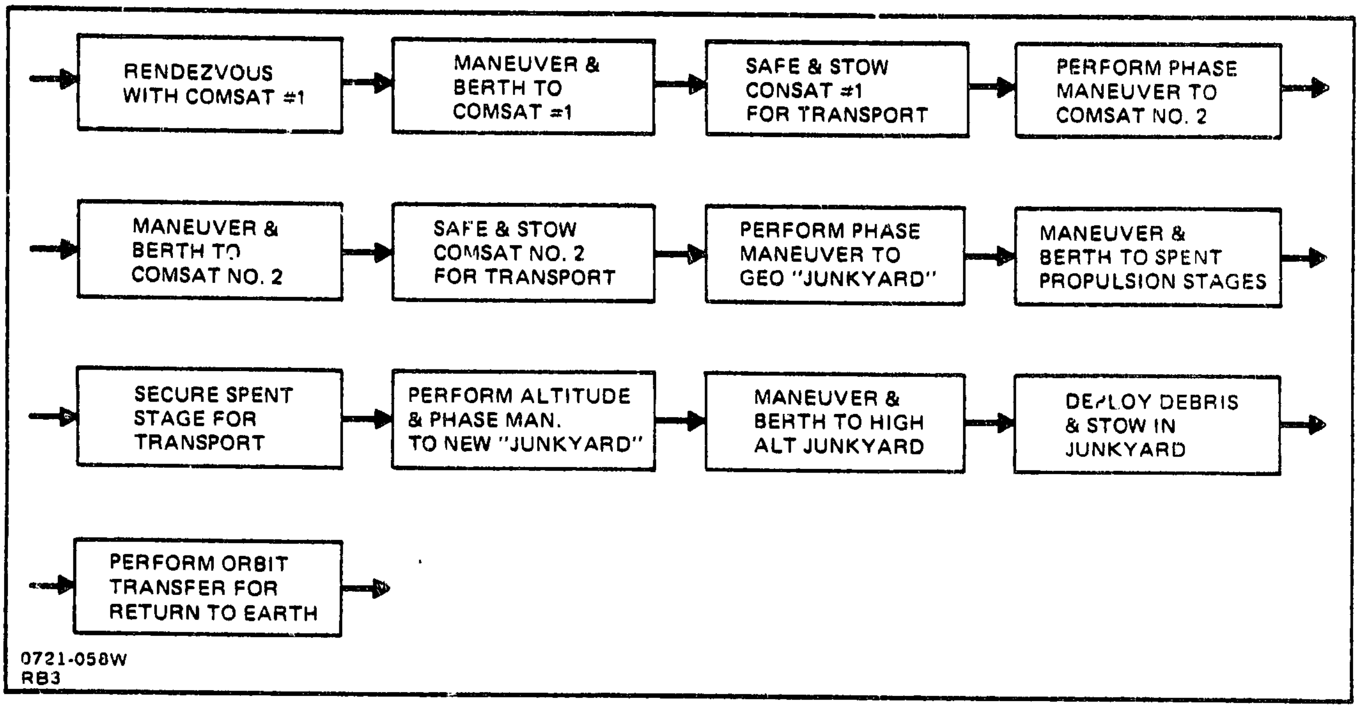


Fig. 4.13-1 DR1 – Debris Removal From GEO

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MANEUVER & BERTH TO COMSAT NO. 1	(1:20)	IVA		NAV & GUIDANCE OF MOTV TO BERTH WITH STABLE SAT.	
– PREPARE FOR FINAL APPROACH	:40				
– INSPECT SATELLITE	:20				
– MANEUVER TO BERTHING ATTITUDE	: 5				
– ACTIVATE & POSITION BERTHING SYSTEM	: 5				
– PERFORM CLOSING MANEUVER & BERTH	:10				
• SAFE & STOW COMSAT NO. 1 FOR TRANSPORT	(1:45)	IVA		OPERATE MANIPULATORS	
– SHUTDOWN SAT. POWER SUPPLY	:30				
– VENT PROPELLANTS/FLUIDS AS NEEDED	:20				
– REMOVE, SAFE & STOW APPENDAGES	:25				
– STOW SATELLITE	:30				
• PERFORM 22½° PHASING MANEUVER TO COMSAT NO. 2	(48:00)	IVA		NAV & GUIDANCE	
• REPEAT STEPS 1 & 2 FOR COMSAT NO. 2	(3:05)	IVA		OPERATE MANIPULATORS	
• PERFORM 22½° PHASING MANEUVER TO GEO JUNKYARD	(48:00)	IVA		NAV & GUIDANCE	
• REPEAT STEPS 1 & 2 TO RETRIEVE SPENT PROPULSION STAGE	(3:05)	IVA		OPERATE MANIPULATORS	
• PERFORM ALTITUDE & PHASING MANEUVER TO HIGH ALTITUDE JUNKYARD	(24:00)	IVA		NAV & GUIDANCE	
• MANEUVER & BERTH TO JUNKYARD	(1:20)	IVA		NAV & GUIDANCE	
• DEPLOY DEBRIS & STOW IN JUNKYARD	(1:00)	IVA		MANIPULATOR OPERATIONS	
TOTAL	131:35				

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Fig. 4.13-2 DR1-Functions, Time, & Tasks

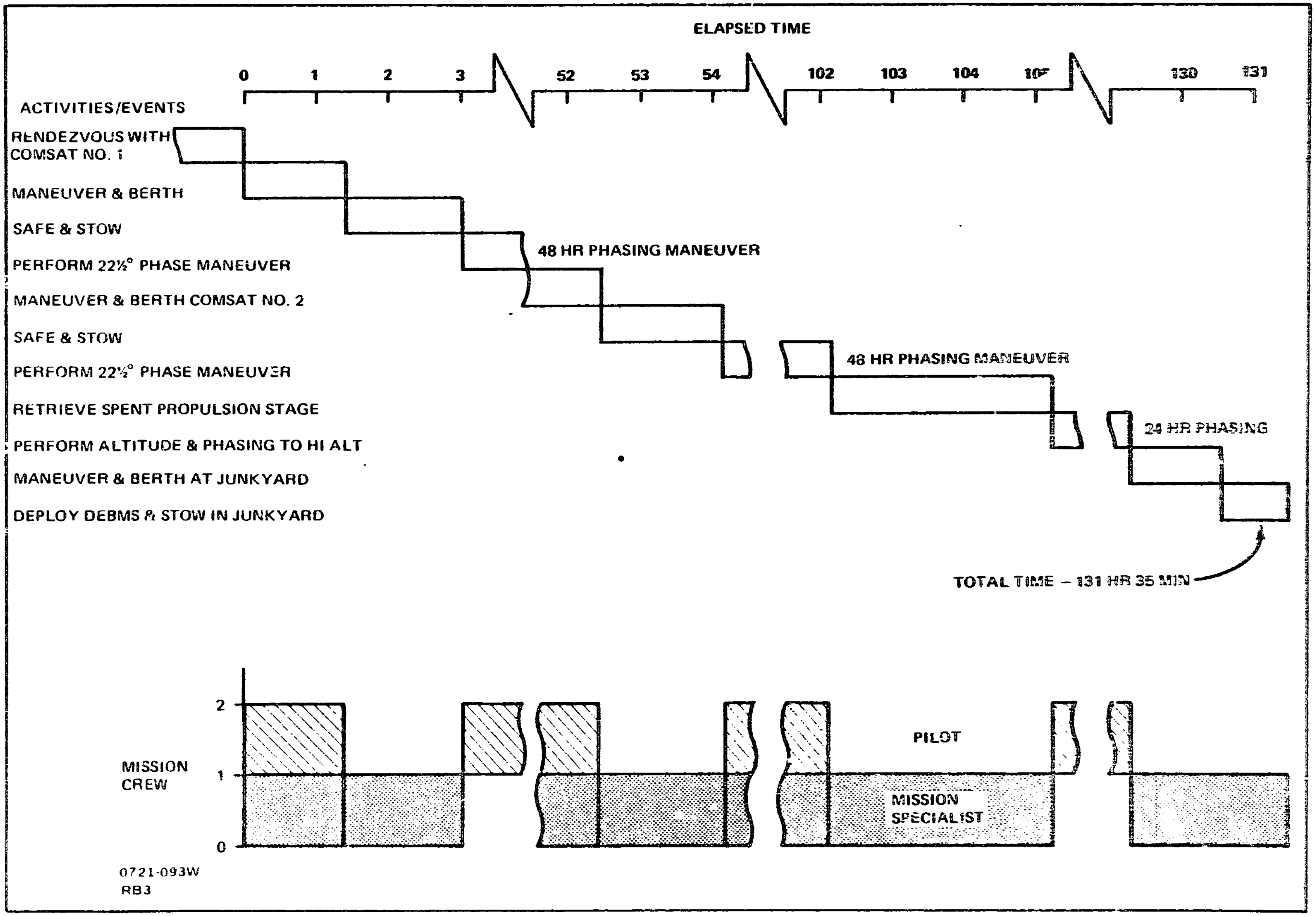

Fig. 4.13-3 DR1-Timeline & Crew Requirements

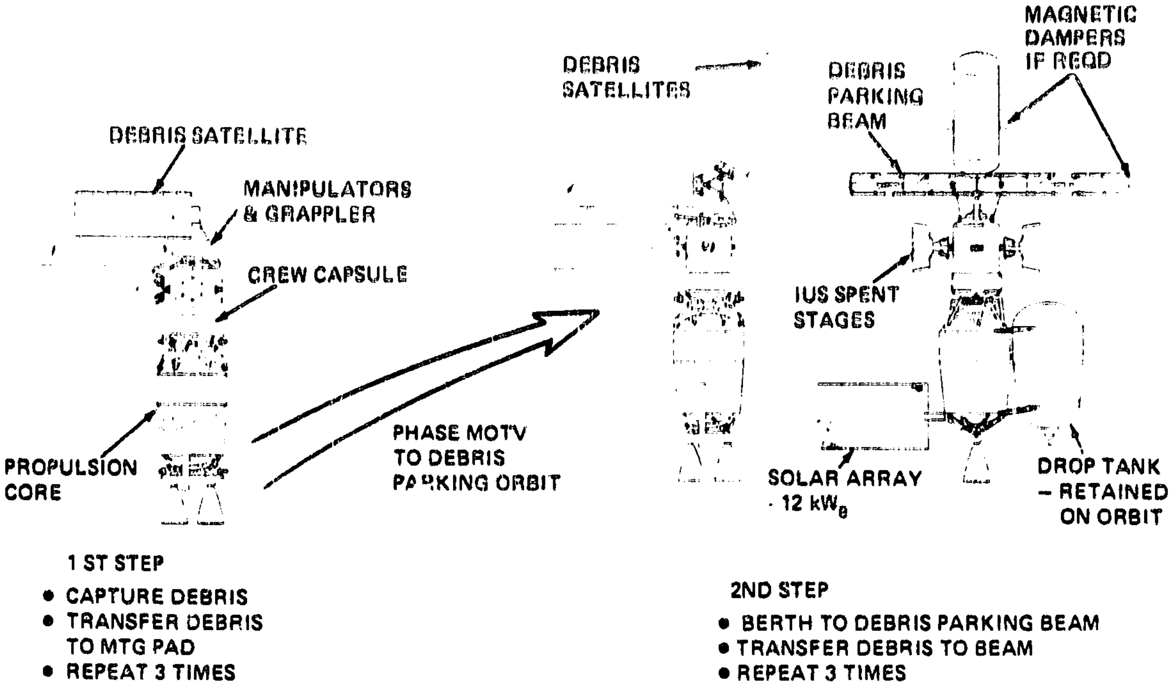

Fig. 4.13-4 On-Orbit Scenario for Mission DRI

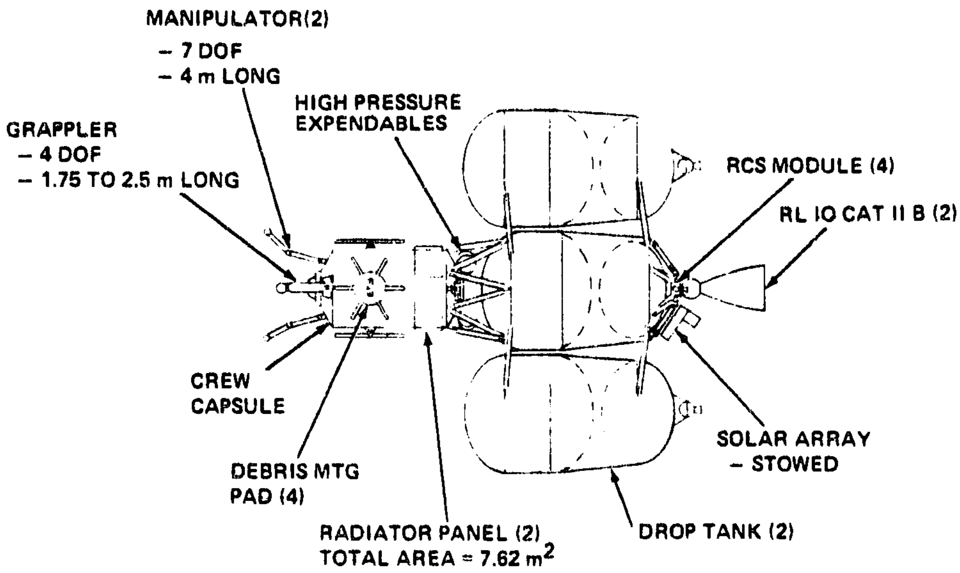

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Fig. 4.13-5 Conf For Mission DR1

	CREW CAPSULE	PROP'LS'N CORE	DROP TANKS (2)	MISSION EQUIP'T GENERAL PURPOSE	MISSION EQUIP'T DEDICATED
DRY WEIGHT	3685	3289	2950	921	125
CREW/CONSUMABLES	307	61			
RESERVES/RESIDS		296	470		
BURNOUT WEIGHT	3992	3646	3420	921	125
MAIN PROP – (CAPACITY)		(17,500)	(64,640)		
– LOADING		16,374	62,338		
ACPS PROP		1899			
MISC		145			
MOTV WEIGHT	3992	22,064	65,758	921	125
TOTAL MOTV WEIGHT	←		92,860		→

1776-431W

Fig. 4.13-6 DR1 Summary Wt Statement, kg

CREW CAPSULE		WEIGHT, kg
STRUCTURE		1515
THERMAL PROT		48
EPS		25
AVIONICS		149
ECLS		499
CREW ACCOM		706
PROPULSION		6
RECOVERY		–
CONTINGENCY	(25%)	737
TOTAL DRY WEIGHT		3685
CREW	(2)	163
CONSUMABLES	(8.3 DAYS)	144
BURNOUT WEIGHT		3992

NOTES
- MANIPULATORS, ETC., CHARGED TO GEN PURPOSE MISSION EQUIP.
- EPS SUBSYS IS POWER DISTR ONLY – REMAINDER OF SUBSYS IN PROP. CORE

1776-432W

Fig. 4.13-7 DR1 Wt Statement (Crew Capsule)

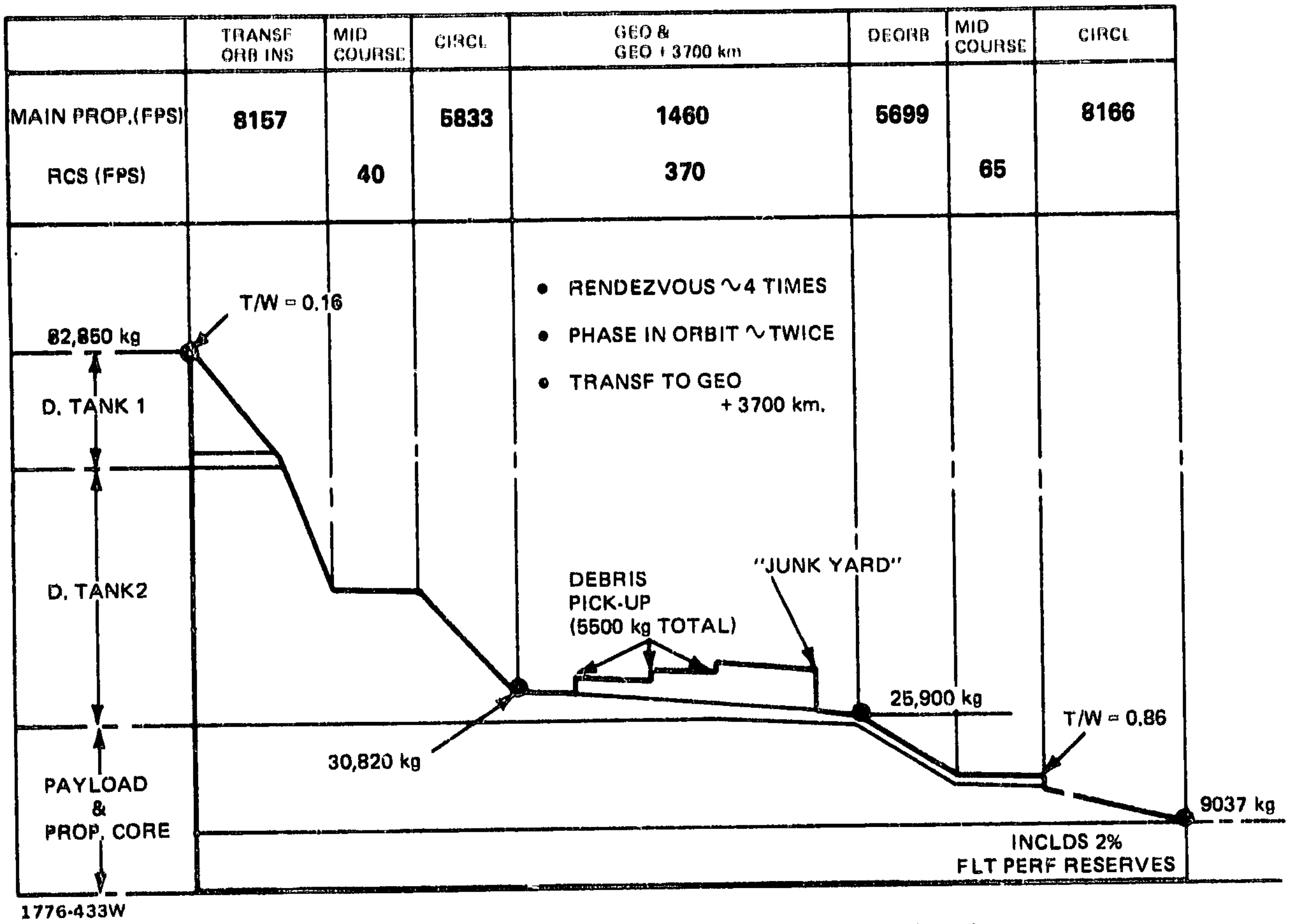


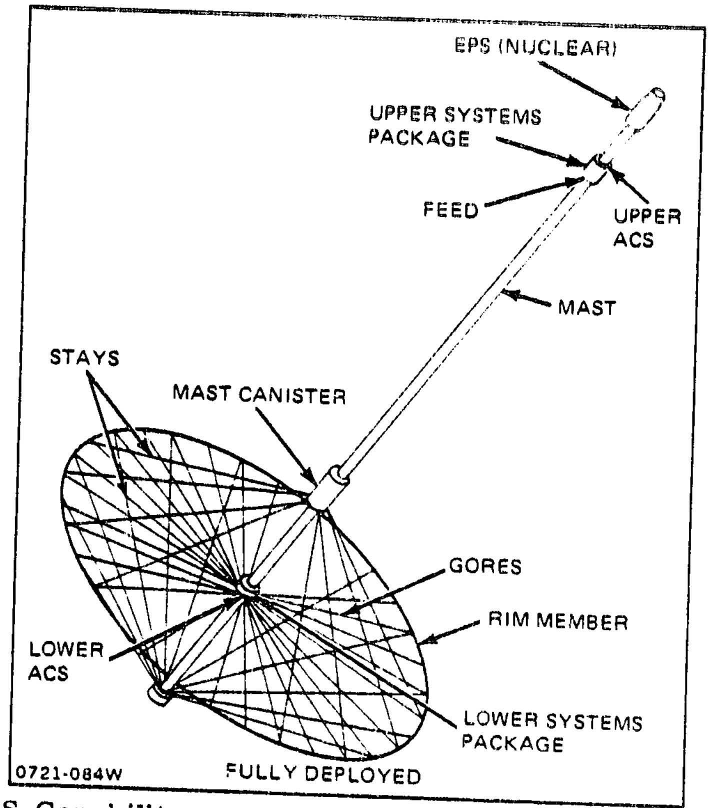
Fig. 4.13-8 Performance Data – Debris Removal Mission (DR1)

4.14 GENERIC MISSION C1 - UNFOLDING WIRE WHEEL ANTENNA IN GEO

Mission Description: A wire wheel antenna approximately 236 m in diameter is transported to GEO folded. The MOTV crew will unload the antenna, initiate deployment, observe the unfolding, and initiate any corrective action should a problem arise. The entire package as shown in the figure will then undergo final checkout prior to the MOTV flight back to earth.

Characteristics:

Weight	10,000 kg
Size	
Diameter	236 m
Length	354 m
Power	50 kW
Orbit	GEO
Timeframe	1990
Life/Servicing Period	10/3 yr



Rationale for MTOV Use:

- Launch Payload Is Beyond IUS/SSUS Capability
- LEO to GEO transfer g's are .3/.5 with MOTV compared to 2-g using clustered IUS
- To assure mission success with IUS transfer the payload must be unfolded and checked in LEO, then transported unfolded to GEO. With MOTV, payload can be transferred and then unfolded and checked out in GEO. Transfer g's are lower using MOTV resulting weight savings, but with the same or greater chance of mission success
- Manned monotoring of the unfold sequence and the ability to intervene on an as required basis.
  - avoids ultra complex remote automation
  - redundant mechanism
  - provides higher probability of success

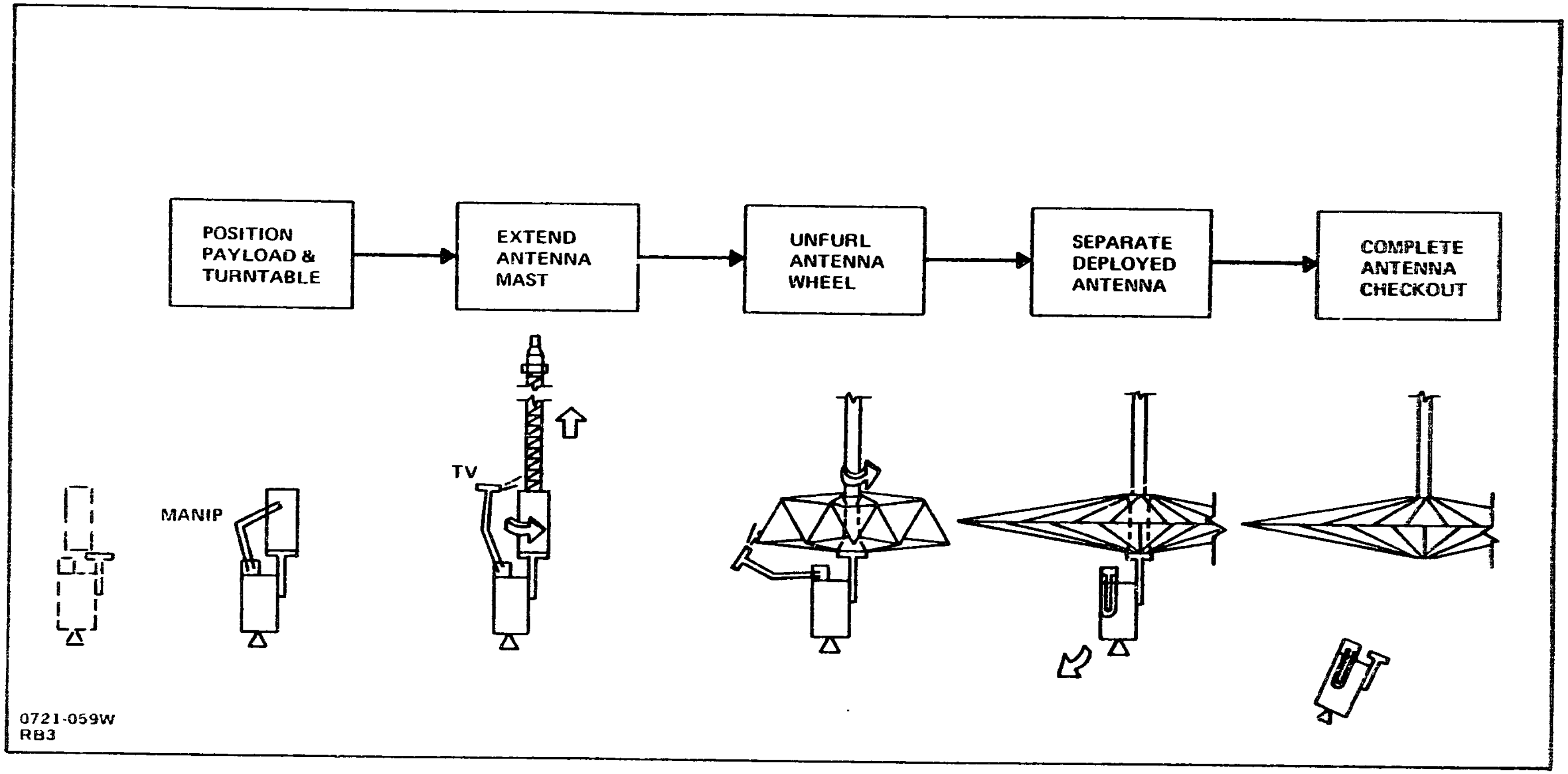


Fig. 4.14-1 C1 – Unf Fig. 4.14-1 C1 – Unfold Wire Wheel Antenna

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	CREW TASK	REMARKS
• POSITION PAYLOAD & TURNTABLE	(:20)			
– CHECKOUT PAYLOAD STATUS	:05	IVA	OPERATE & MONITOR	
– CHECKOUT TURNTABLE STATUS	:05	IVA	CONTROLS & DISPLAYS	
– RELEASE PAYLOAD/TURNTABLE SUPPORTS	:10	IVA		MANIPULATOR
– REPOSITION PAYLOAD & TURNTABLE FOR UNFURLING		IVA		MAY BE REQD
• EXTEND ANTENNA MAST	(2:30)			
– ACTIVATE & POSITION TV MANIPULATOR	:05	IVA	OPERATE & MONITOR	
– ACTIVATE/VERIFY ANTENNA MAST STATUS	:05	IVA	CONTROLS & DISPLAYS	
– INITIATE MAST EXTENSION (~ 3m/MIN)	2:00	IVA	CONTROL RATE OF EXTENSION	PARALLEL
– ROTATE & INSPECT DEPLOYED MAST LINKAGE	:20	IVA	VERIFY LATCHING & SWITCHING	ACTIVITIES
– (ADJUST MAST LINKAGE REMOTELY – IF NEEDED)	––	IVA	OPER MANIPULATOR END EFFECTOR	CONTINGENCY
– ADJUST MAST LINKAGE WITH EVA – IF NEEDED)	––	EVA	LEO SUIT, CABIN DEPRESS TETHER/MMU OPER-INSPECT & REPAIR	10 TIMES @ 2 MIN EA LAST REPORT MAYBE ONCE/FLT
• UNFURL ANTENNA WHEEL	(3:00)			
– REPOSITION TV MANIPULATOR	:05)	IVA	OPERATE & MONITOR	
– ACTIVATE/VERIFY ANTENNA WHEEL STATUS	:15	IVA	CONTROLS & DISPLAYS	
– INITIATE WHEEL UNFOLDING (~ 1m/MIN)	2:00	IVA	CONTROL RATE OF UNFOLDING	PARALLEL
– ROTATE & INSPECT WHEEL GORES & LINKAGE	:40	IVA	VERIFY LATCHING & SWITCHING	ACTIVITIES
– (ADJUST LOWER WHEEL HUB LINKAGE REMOTELY)	––	IVA	OPER MANIP END EFFECTOR	CONTINGENCY
– (ADJUST UPPER WHEEL HUB LINKAGE W/EVA)	––	EVA	LEO SUIT CABIN DEPRESS MMU OPER INSPECT & REPAIR	CONTINGENCY (MAYBE ONCE/FLT)
• SEPARATE DEPLOYED ANTENNA	(:30)		OPERATE VARIOUS C & Ds FOR MANIP, TURNTABLE & RELEASE MECH & PAYLOAD SYS	
– SAFE/STOW MANIPULATOR	:15	IVA		
– SAFE/STOW TURNTABLE		IVA		
– CHECKOUT PAYLOAD RELEASE		IVA		
– ACTIVATE/CHECK OUT ANTENNA SUBSYS	:15	IVA		
– MANEUVER TO SEPARATION ATTITUDE		IVA	OPERATE MOTV FLT SYS	
– RELEASE DEPLOYED ANTENNA		IVA		
• COMPLETE ANTENNA CHECKOUT	(1:20)			
– MANEUVER TO VERIFY ANTENNA CONFIGURATION	:20	IVA	– 4π VISUAL INSPECT	
– PERFORM PHOTOGRAMETRIC CALIBRATION	:30	IVA	– OPER MANIP & STERO CAMERAS	
– SUPPORT ANTENNA SPACE-GROUND C/O	:30	IVA	– MONITOR ANTENNA SYS	
TOTAL	7:40			

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Fig. 4.14-2 C1-Functions, Time, & Tasks

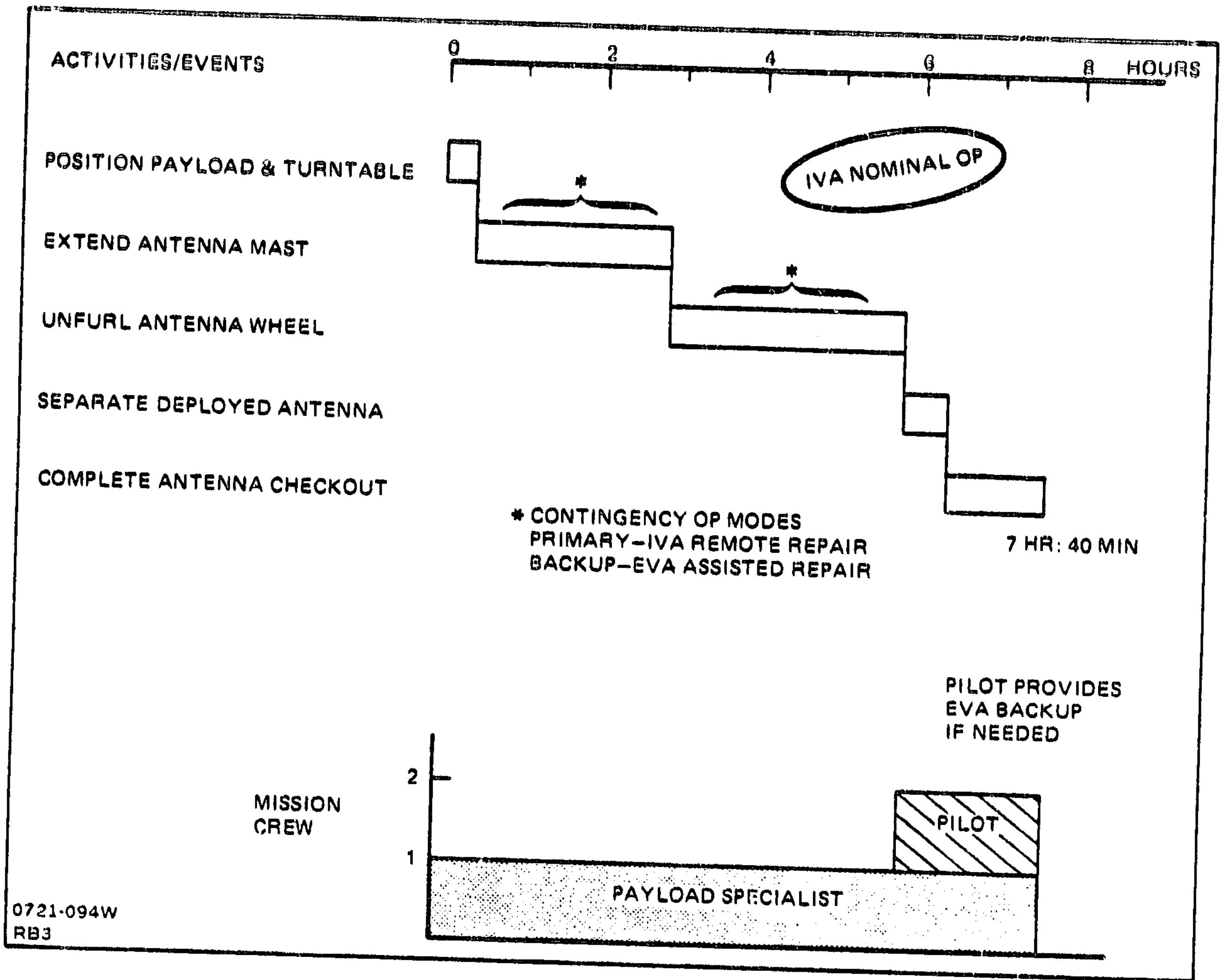
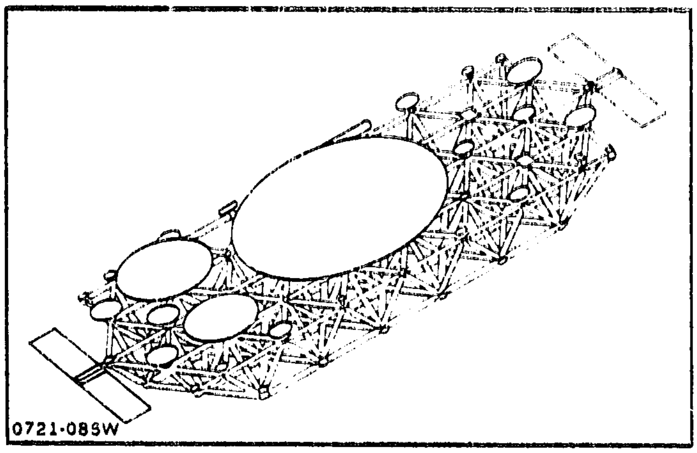


Fig. 4.14-3 C1-Timeline & Crew Requirements

4.15 GENERIC MISSION C2 - UNFOLD TETRAHEDRON PLATFORM FOR MOUNTING COMMUNICATIONS ANTENNAS

Mission Description: A large tetrahedron structure together with a complement of various sized antenna will be transported to GEO. The main structure and antenna will arrive folded in a number of separate packages each of which must be unloaded, unfolded, and assembled together to form the final satellite as shown in the figure. Subsequent checkout by the crew is then initiated before departure back to earth.

Characteristics:



Weight	16,000 kg
Size	
Length	85 m
Width	31 m
Orbit	GEO
Timeframe	Mid 90s
Life/Servicing Period	30/3 yr

Rationale for MOTV Use:

- Payload weight is beyond IUS.
- Manned GEO assembly vs LEO assembly and unmanned transfer has the following benefits:
  - effects of transfer g's are minimized saving weight
  - simpler and higher fidelity checkout possible
  - avoids problems of day/night assembly and possible thermal gradient problems thus eliminating difficulty in assembly due to differential expansion
  - antenna alignment is more precise
  - mission success is enhanced.

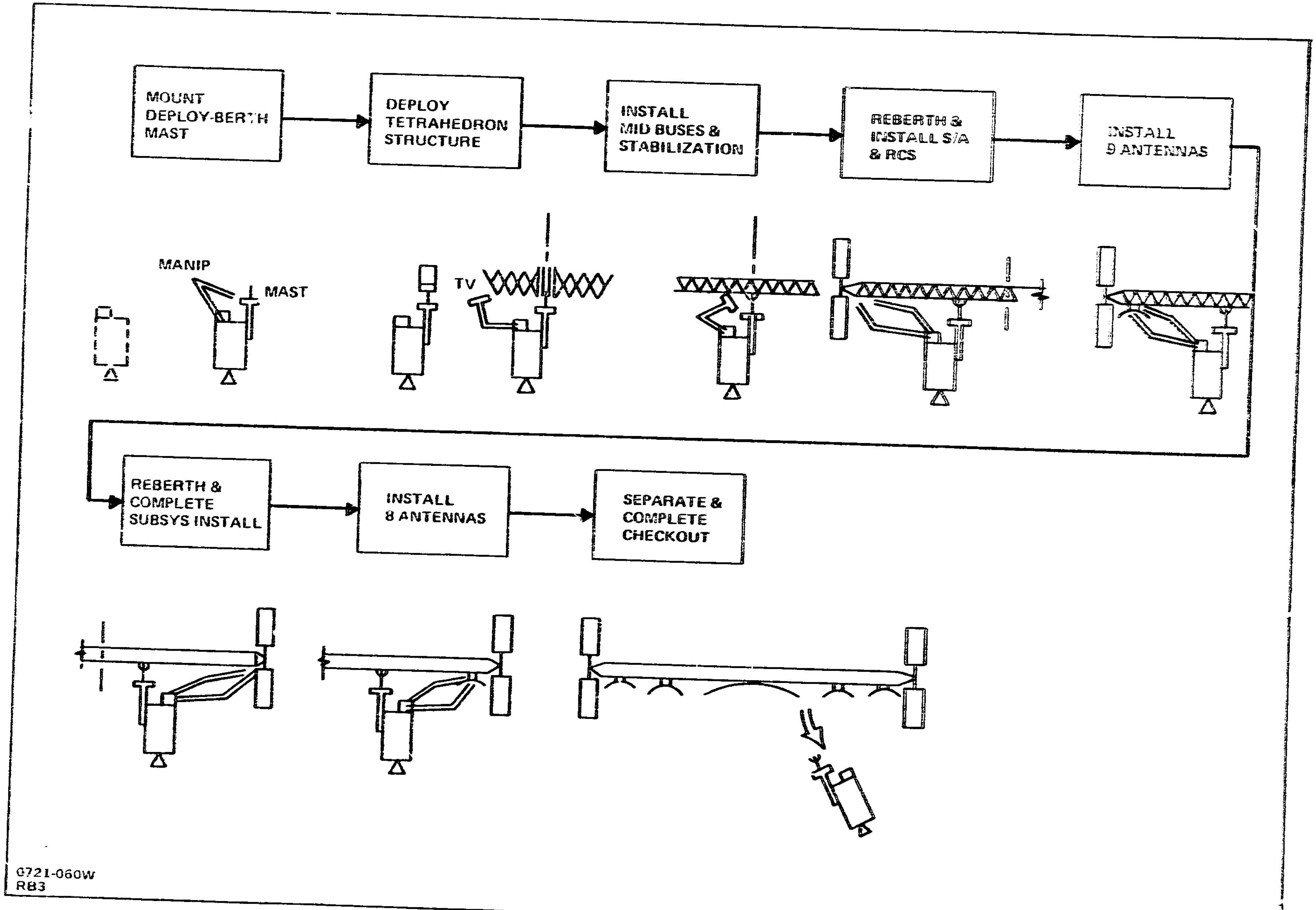


Fig. 4.15-1 C2-Assemble Communication Platform with Deployable Structure

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MOUNT DEPLOY-BERTH MAST	(:30)				
– ACTIVATE & POSITION MANIPULATORS(2)	:10	IVA		OPERATE & MONITOR	5 MIN EACH
– CHECKOUT DEPLOY-BERTH MAST STATUS	.05	IVA		CONTROLS & DISPLAYS	
– REPOSITION MAST FOR USE	:15	IVA			
• DEPLOY TETRAHEDRON STRUCTURE	(1:40)				
– UNSTOW, TRANSLATE FOLDED STRUCTURE	:10	IVA		OPERATE MANIP ACTIVATE	
– MOUNT FOLDED STRUCTURE ON MAST	:30	IVA		& MONITOR TRUSS DEPLOY	
– RELEASE TETRATRUSS RESTRAINTS					
– ROTATE MAST & INSPECT DEPLOYED STRCUTURE	1.00	IVA		MEASURE SURFACE FLATNESS & VERIFY LATCHING IF NEEDED	~ 12 DEG/MIN BOTH SIDES
-- (ADJUST STRUCTURE LATCHING REMOTELY IF NEEDED)				OPER MANIP OR MANEUVER OTV TO AID LATCHING	
– (ADJUST LATCHING WITH EVA – IF NEEDED)		EVA		LEO SUIT CABIN DEPRESS TETHER/MMU OPER INSPECT & REPAIR	LAST RESORT
• INSTALL MID-BUSSES & STABILIZATION	(2:20)				
– ATTACH & C/O MID DATA BUS	:30			OPERATE MANIP ATTACH STAND-OFFS & ROUTE BUSING	
– ATTACH & C/O MID POWER BUS					
-- UNSTOW, INSTALL & C/O STABILITY CYL MOD	:50				UNSTOW 10 MECH & ELECT 1 INSTALL & C/O 40
– ATTACH & CONNECT POWER PACK	:40				
– ACTIVATE & VERIFY PLATFORM STABILITY	:05				
- SAFE/STOW MANIPULATORS	:15				
• REBERTH & INSTALL S/A & RCS	(5:00)	IVA			
– RELEASE MAST BERTHING DEVICE	:10			OPERATE/MONITOR	
– MANEUVER TO NEXT ASSEMBLY POSITION				C & D	
– REBERTH & REPOSITION MANIPULATORS	:20			OPERATE MANIPULATORS	
– INSPECT END DEPLOYED STRUCTURE	:30				
– ATTACH & C/O END BUSSES (DATA & POWER)	1:20				
– INSTALL & DEPLOY SOLAR ARRAY	1:00				UNSTOW INSTALL C/O DEPLOY 30 SEC EACH
– INSTALL (2) REACTION CONTROL MODULES	1:40			10 + 40 + 10	
– CHECKOUT END SUBSYSTEMS	:20			OPERATE C & Ds	

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Fig. 4.15-2 C2–Functions, Time, & Tasks

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• INSTALL 9 ANTENNAS	(9:00)				
– INSTALL & C/O 30 m ANTENNA SYS	:50				
– INSTALL & C/O (2) 12 m ANTENNAS	1.40				
– INSTALL & C/O 10 m ANTENNA	:50				
– INSTALL & C/O (2) 4.5 m ANTENNAS	1:40				
– INSTALL & C/O (3) 3 m ANTENNAS	2:30				
– DEPLOY 9 ANTENNA SYSTEMS	1.20				1 MIN METER RADIUS 82 METER
– SAFE/STOW TWO MANIPULATORS	:10				
• REBERTH & COMPLETE SUBSYS INSTALL	(5:00)				
– RELEASE BERTHING DEVICE					
– MANEUVER TO NEXT ASSEMBLY POSITION	:10				
– REBIRTH & REPOSITION MANIPULATORS	:20				
– INSPECT REMAINING DEPLOYED STRUCTURE	:30				
– ATTACH & C/O REMAINING END BUSES (DATA & POWER)	1:20				
– ATTACH & DEPLOY SOLAR ARRAY	1:00				
– ATTACH REACTION CONTROL MODULES	1:40				
– CHECKOUT END SUBSYSTEMS	:20				
• INSTALL 8 ANTENNAS	(7:25)				
– INSTALL & C/O (3) 12 m ANTENNAS	2:30			OPERATE VARIOUS C & DS	
– INSTALL & C/O (2) 4.5 m ANTENNAS	1:40				
– INSTALL & C/O (3) m ANTENNAS	2.30				
– DEPLOY 8 ANTENNA SYS	:30				
– SAFE/STOW TWO MANIPULATORS	:15				
• SEPARATE & COMPLETE CHECKOUT	(1:10)				
– CHECKOUT PLATFORM SUBSYS	:15	IVA		OPERATE C & DS	
– RELEASE BERTHING DEVICE					
– SAFE/STOW BERTHING DEVICE	:20	IVA			
– MANEUVER TO VERIFY PLATFORM CONFIG					
– SUPPORT PLATFORM SPACE-GROUND C/O	:35	IVA			
TOTAL	32:05				

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Fig. 4.15-2 C2-Functions, Time, & Tasks (contd)

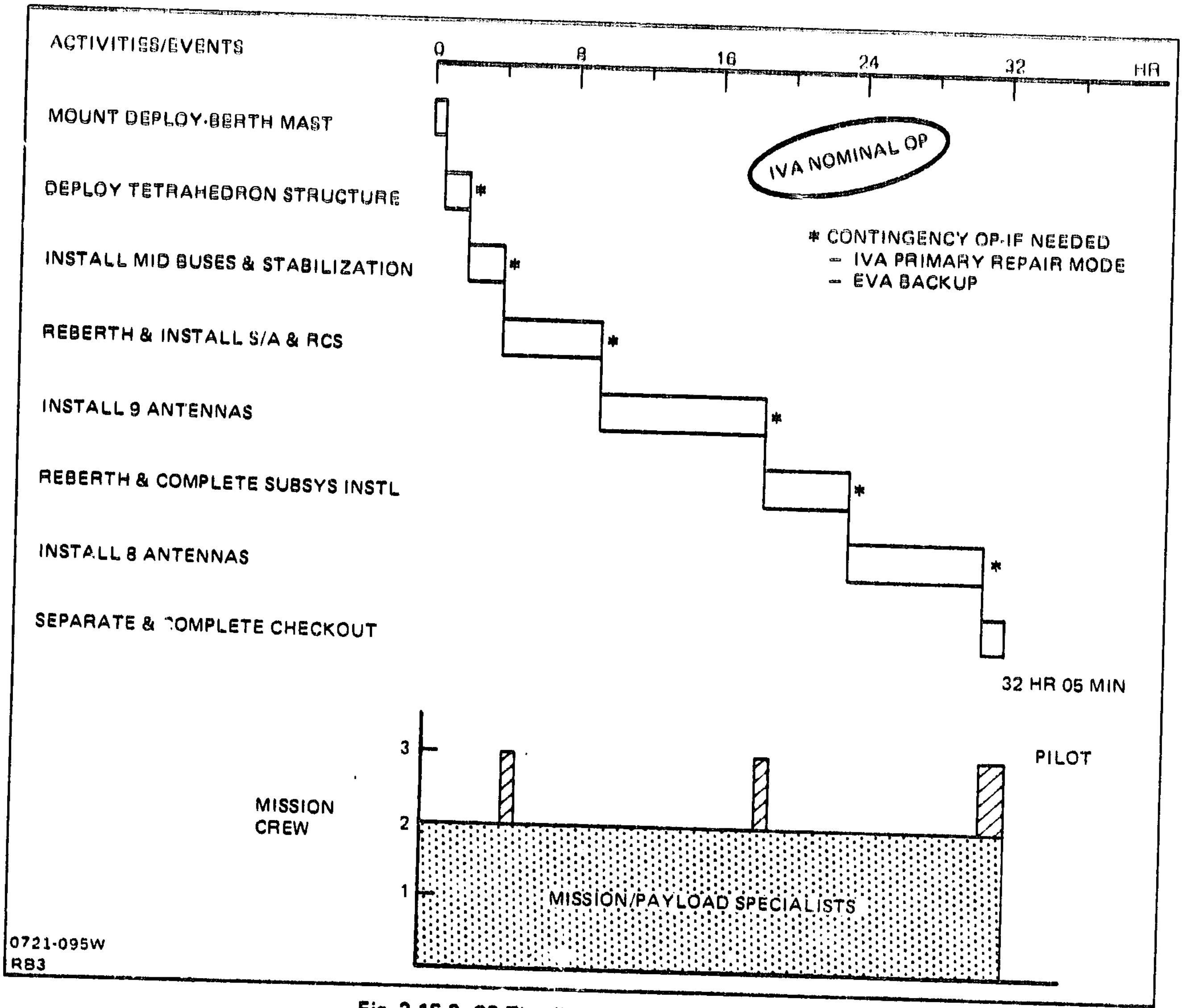


Fig. 2.15-3 C2-Timeline & Crew Requirements

c-2

4.16 GENERIC MISSION C3 - PREFAB PLATFORM FOR MOUNTING COMMUNICATIONS ANTENNAS

Mission Description: A space platform similar to that described in Generic Mission C2 is constructed in GEO using Prefab "Dixie Cup" structural members. Upon arrival in GEO the stowed packages of "Dixie Cup" members are unloaded from the MOTV, fabricated into structural members and assembled to form the platform. The various antenna are then mounted to the platform together with a common power supply and electronics. The final configuration is shown in the figure.

Characteristics:

Weight . . . . 17,000 kg

Size

Length . . . . 99 m

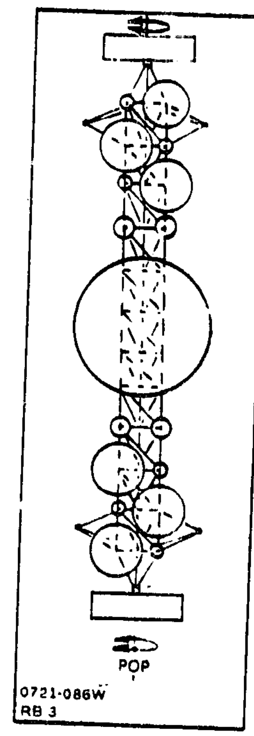
Width . . . . 11 m

Power . . . .

Orbit . . . . GEO

Timeframe . . . . Mid 90s

Life Servicing . . . . 30/3 yr



Rationale for MOTV Use:

- Payload weight is beyond the capability of the IUS.
- Manned GEO assembly vs LEO assembly and unmanned transfer has following benefits:
  - effects of transfer g's are minimized saving weight
  - simpler and higher fidelity checkout possible
  - gravity gradient loads reduced by a factor of 200 in GEO minimizing attitude hold propellant requirements during construction
  - antenna alignment is more precise
  - mission success is enhanced.

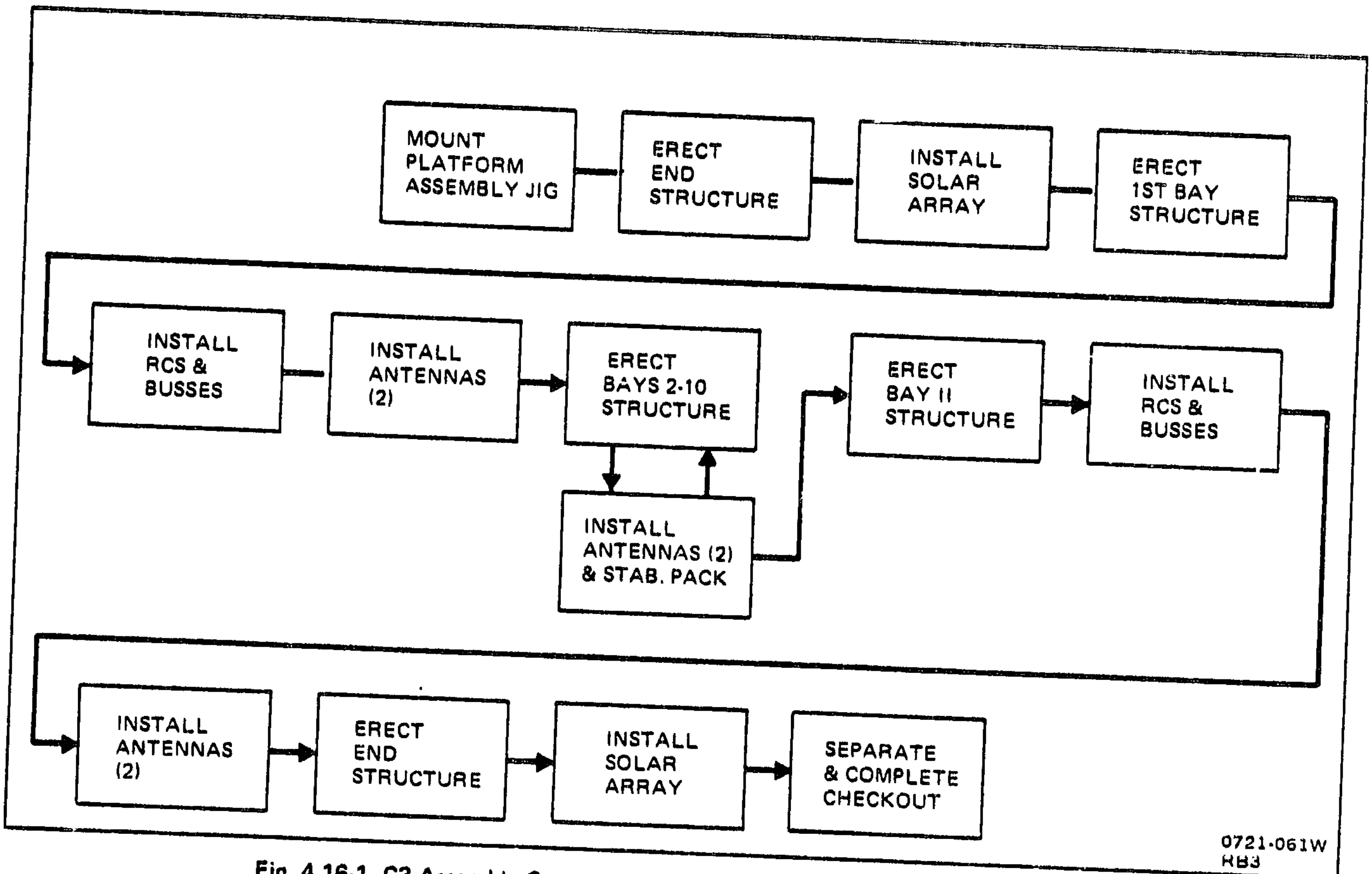


Fig. 4.16-1 C3-Assemble Communication Platform with Prefab Structure

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MOUNT PLATFORM ASSY JIG	(:60)	IVA		2 MAN CREW	
– ACTIVATE MANIPULATOR SYS	:10		2	+ PILOT	
– MOUNT JIG	:40		2		
– TEST JIG & CLAMPS	: 5		1		
– MOUNT BUS REELS (2)	: 5		2		2 IN 11
• ERECT END STRUCTURE	(:51)				
– INSTALL FITTINGS IN JIG CLAMPS					
– INSTALL LATERAL BEAMS IN JOINT FIT.	:36		2		
– INSTALL DIAGONAL BEAMS IN JOINT FIT.					
– CONNECT FWD ENDS OF DIAGONALS 10	:10		2		
– EXTEND BUSSES & CONNECT	: 5		2		2 IN 11
• INSTALL SOLAR ARRAY	(1:00)				
– INSTALL S/A UNIT			2		
– CONNECT S/A TO BUSSES	:50		1		2 IN 11
– DEPLOY S/A	:10		1		
• ERECT 1ST BAY STRUCTURE	(:57)				
– EXTEND JIG (DEPLOY BUSSES)	: 2		2		
– INSTALL JOINT FITTINGS IN REAR JIG CLAMPS			2		
– INSTALL LATERAL BEAMS	:25		2		3 IN 11
– INSTALL LONGITUDINAL BEAMS			2		
– INSTALL DIAGONAL BEAMS	:30		2		
• INSTALL RCS & BUSSES	(1:35)				
– INSTALL RCS BRACES IN BAY STRUCT					
– ATTACH END FITTING	:35		2		2 SIDES IN 11
– CONNECT OUTER ENDS OF BRACES TO JOINT					
– INST. BUSSES	:10		2		
– INSTALL RCS MODULE	:50		2		
• INSTALL ANTENNAS	(1:48)				
– MOUNT ANTENNA UNITS (2)	1:40		2		1-3 IN, 1-12 IN
– DEPLOY ANTENNAS	: 8		1		
– C/O					

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Fig. 4.16-2 C3–Functions, Time, & Tasks

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• ERECT BAYS 2-10 STRUCTURE	(9:00)				
– RETRACT JIG & RECLAMP	27		1		
– COMPLETE STRUCTURE (SAME AS 1ST BAY STRUCTURE)	8:33		2		
• INSTALL ANTENNAS & STAB. UNIT	10:47				
– MOUNT ANTENNA UNITS (11)	9:10		2		
– DEPLOY ANTENNAS	:47		1		
– MOUNT STABILIZATION UNIT	:50		2		
• ERECT BAY 11 STRUCTURE (SAME AS BAYS 2-10)	(1:00)		–		
• INSTALL RCS & BUSSES (SAME AS 1ST BAY STRUCTURE)	(1:35)		2		
• INSTALL ANTENNAS (4)	(3:34)				
– MOUNT ANTENNA UNITS	3:20		2		
– DEPLOY ANTENNAS	:14		1		2-3 IN 1-12 IN 1-10 IN
• ERECT END STRUCTURE	(:48)				
– INST. DIAG. BEAMS IN FRONT JOINT FIT.	:28		2		
– CONNECT REAR OF BEAMS TO JIG MAIN BEAM					
– EXTEND & CONNECT BUSSES	: 5		2		2 IN 11
– STOW BUS REELS	: 5		2		2 IN 11
– STOW JIG REAR BEAMS	:10		2		
• INSTALL SOLAR ARRAY (SAME AS 3)	(1:00)		–		
• SEPARATE & COMPLETE CHECKOUT	(1:10)				
– STOW MANIPULATORS	:15		2		
– MANEUVER TO VERIFY SATELLITE CONF	:20		3		
– SUPPORT SPACE-GROUND CHECKOUT	:35		3		
TOTAL	36:05				

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Fig. 4.16-2 C3—Functions, Time, & Tasks (Contd)

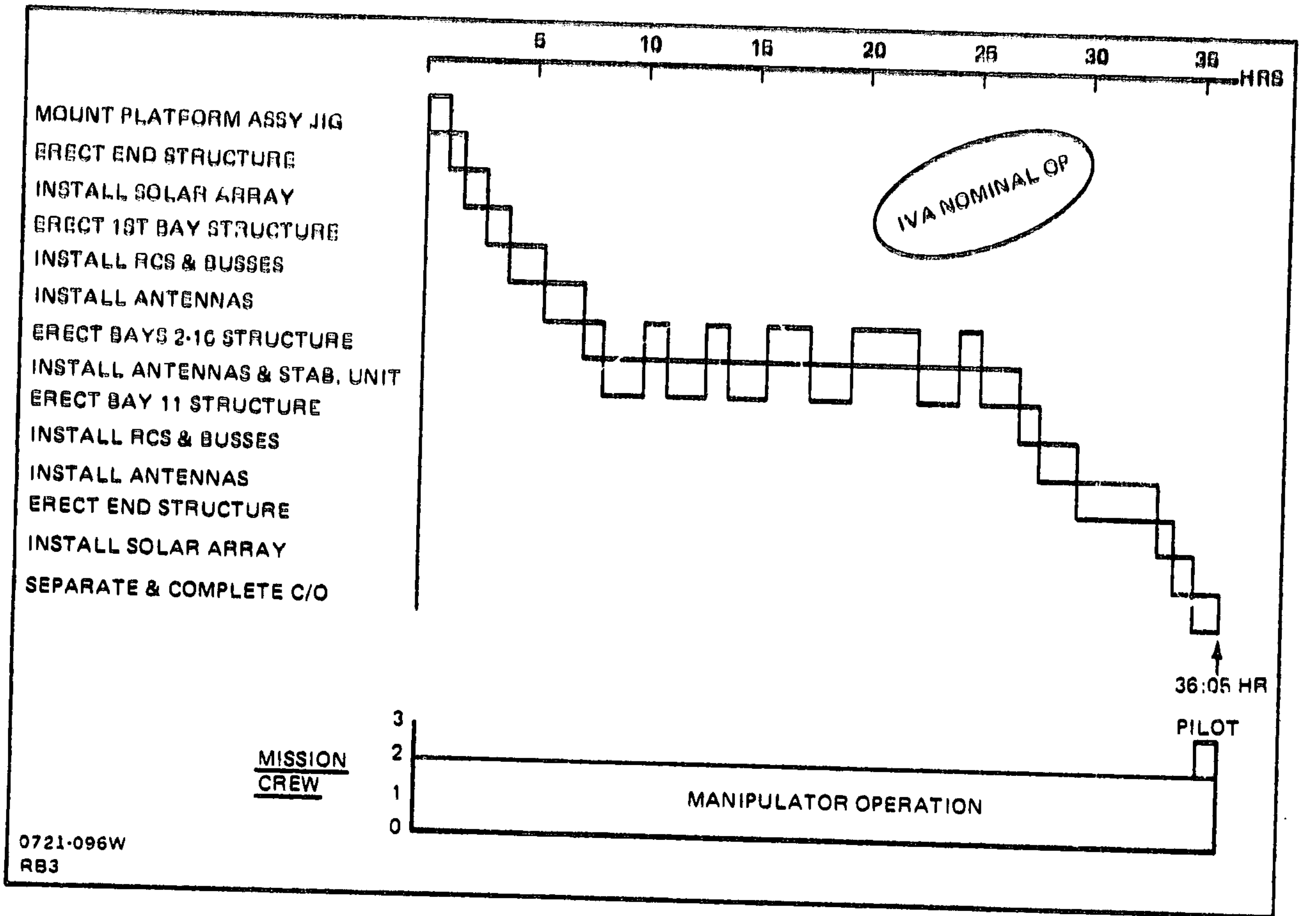

Fig. 4.16-3 C3-Timeline & Crew Requirements

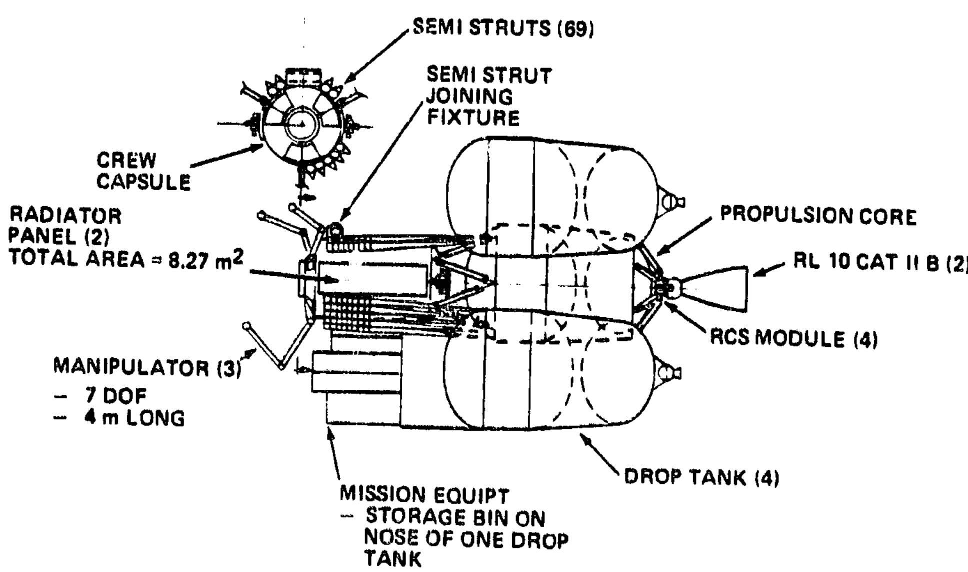

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Fig. 4.16-4 Configuration For Mission C3

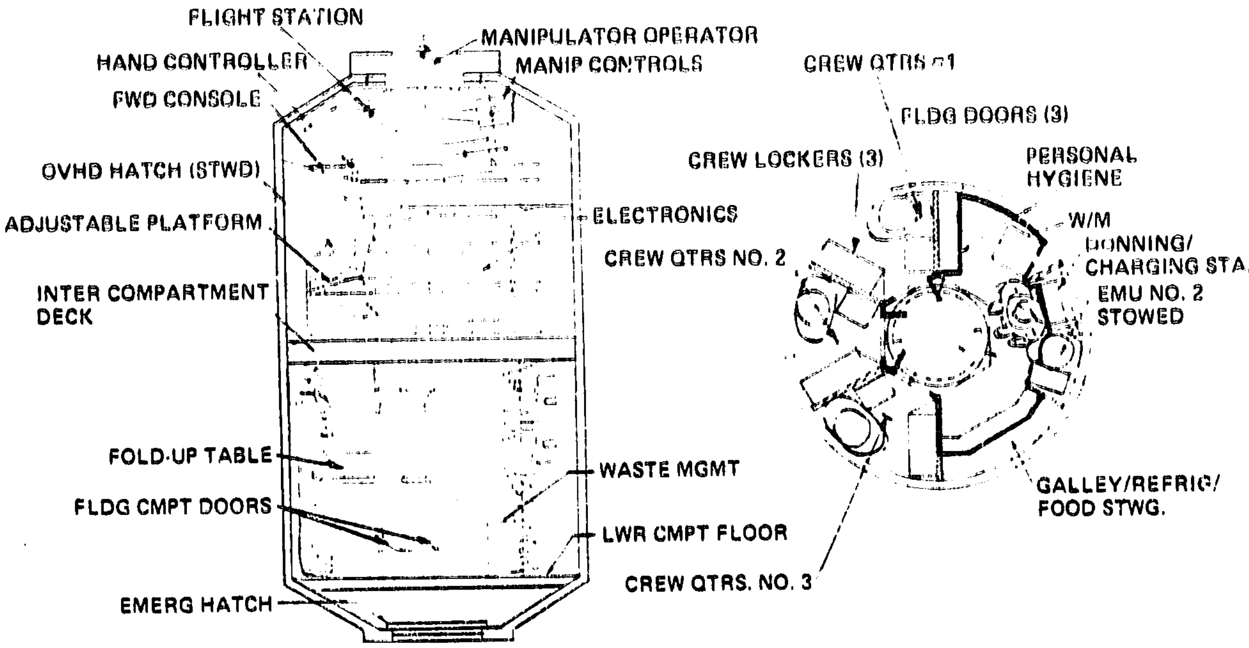

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Figure 4.16-5 APOTV Crew Module (Large) 3 Man (C)

	CREW CAPSULE	PROP'LS'N CORE	DROP TANKS (3)	MISSION EQUIP'T GENERAL PURPOSE	MISSION EQUIP'T DEDICATED
DRY WEIGHT	3795	3357	4425	921	775
CREW/CONSUMABLES RESERVES/RESIDS	410	51 296	705		
BURNOUT WEIGHT	4205	3704	5130	921	775
MAIN PROP – (CAPACITY) – LOADING ACPS PROP MISC		(17,500) (15,735) 1274 145	(81,810) 78,051		17,000
MOTV WEIGHT	4205	20,858	83,181	921	17,775
TOTAL MOTV WEIGHT	126,940				
1776-434W					

Fig. 4.16-6 Construction C3 Summary Wt Statement, kg

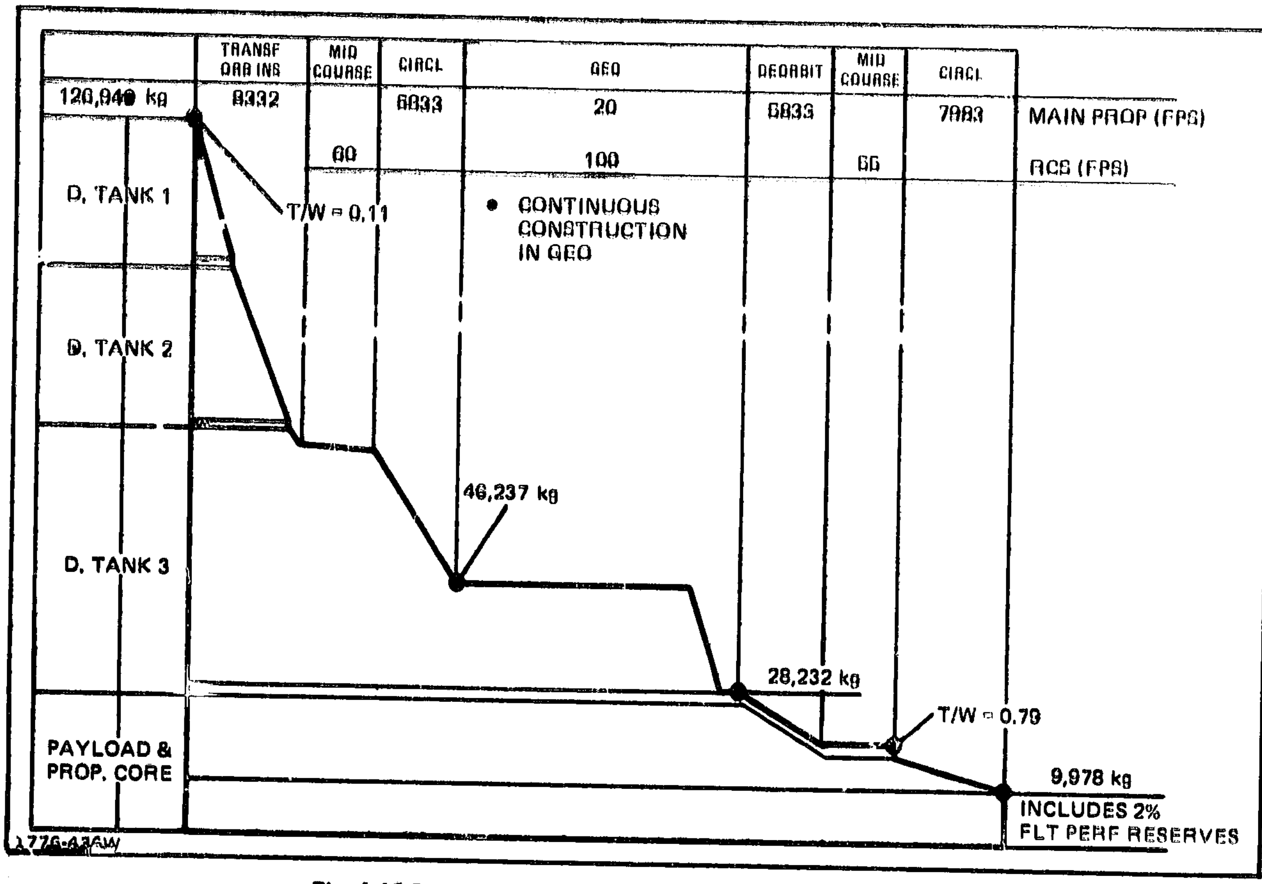

Fig. 4-16-7 Performance Data – Construction Mission (C3)

CREW CAPSULE		WEIGHT, kg
STRUCTURE		1515
THEMAL PROT		48
EPS		25
AVIONICS		149
ECLS		502
CREW ACCOM		791
PROPULSION		6
RECOVERY		–
CONTINGENCY	(25%)	759
TOTAL DRY WEIGHT		3795
CREW	(3)	245
CONSUMABLES	(6 DAYS)	165
BURNOUT WEIGHT		4205

NOTES
- MANIPULATORS, ETC., CHARGED TO GEN PURPOSE MISSION EQUIP.
- EPS SUBSYS IS POWER DISTR. ONLY – REMAINDER OF SUBYS IN PROP. CORE

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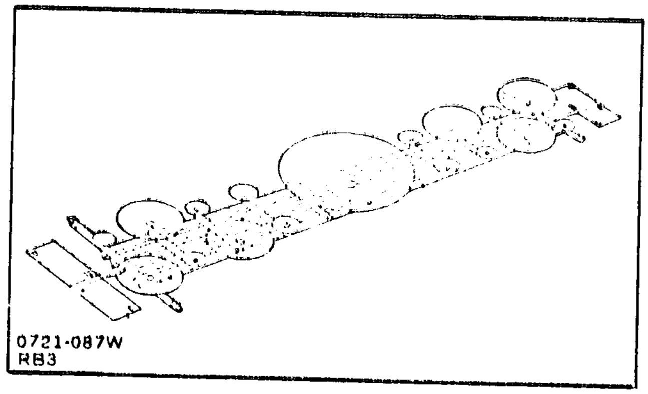
Fig. 4.16-8 C3 Wt Statement (Crew Capsule)

4.17 GENERIC MISSION C4 - AUTOFAB OF A PLATFORM FOR MOUNTING COMMUNICATIONS ANTENNAS

Mission Description: A large space platform similar to that described for Generic Missions C2 & C3 is fabricated using autofab techniques. A beam builder is used to fabricate structural members of the space platform which are subsequently joined together to form the final assembly. The various antennas are mounted to the platform as portions of the platform are completed. Electronics and power supply are also added in a step-by-step fashion to complete the assembly prior to final checkout. The figure depicts the final configuration of the space communications platform.

Characteristics:

Weight	15,000 kg
Size	
SS Length.	95 m
PP Width	11 m
Power	
Orbit	GEO
Timeframe	Mid 90s
Life/Servicing Period	30/3 yr



Rationale for MOTV Use:

- Same as for Generic Mission C3

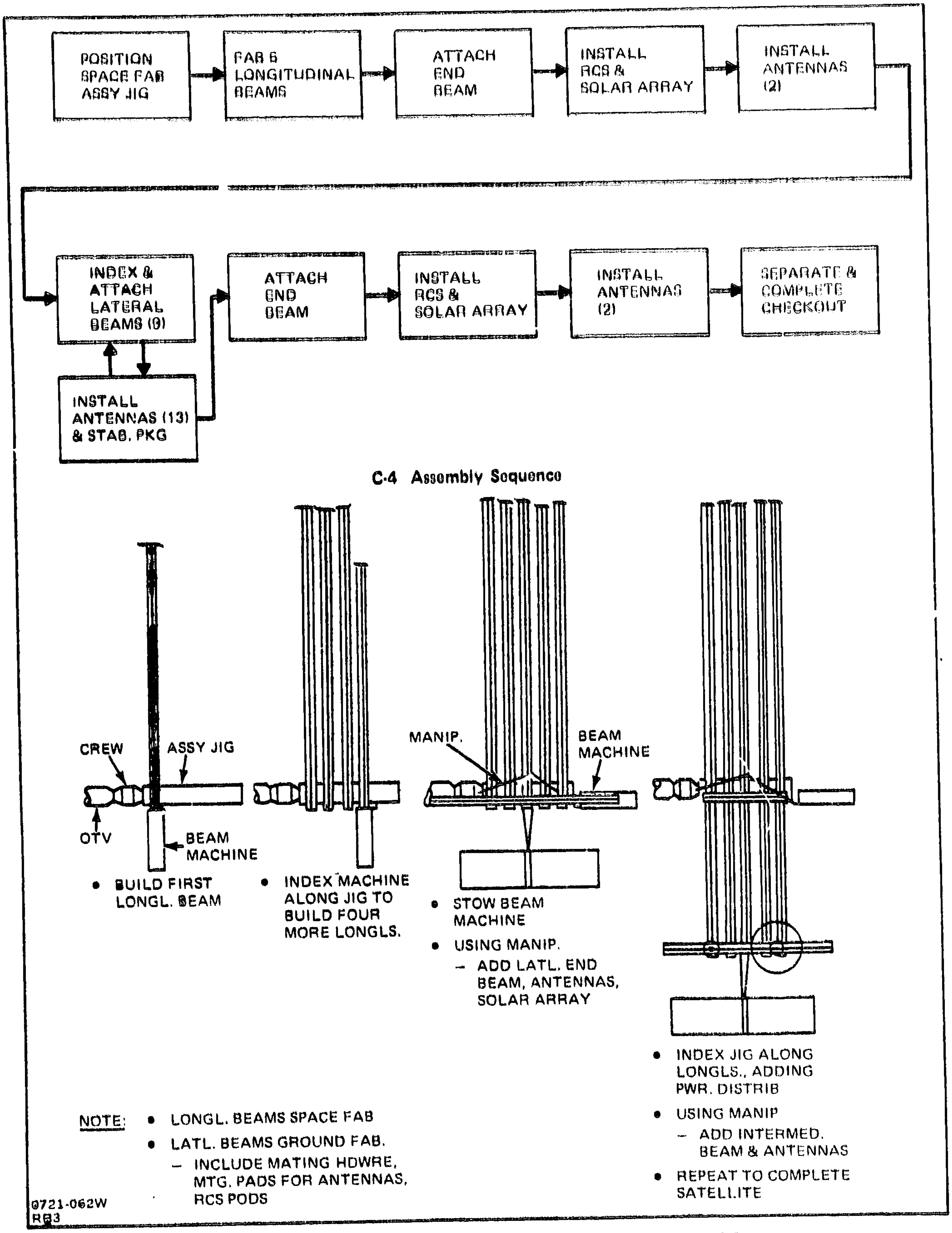


Fig. 4.17-1 C4-Assemble Communication Platform with Space Fabricated Structure

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• POSITION SPACE FAB. ASSY JIG & ABM	(2:20)	IVA			
– ACTIVATE & POSITION MANIPULATORS	:10		2		2 IN 11
– INSTALL JIG PACK	:15		2		
– POSITION BUS DEPLOYERS (2)	:20		2		
– POSITION ABM	:50		2		
– CHECK ABM OPERATIONS	:10		1		
• FAB 5 LONGITUDINAL BEAMS	(8:13)	IVA			
– BAB 95 m BEAM @1m/MIN	7.55		1	OPERATE ABM	REPEAT 5 TIMES
– POSITION & LOCK BEAM TO JIG	:05		1	SWITCHING	
– INDEX ABM LATERALLY	:10		1		
– PARK ABM	.03		1		
• ATTACH END BEAM	(:38)	IVA			
– DETACH & TRANSLATE BEAM W/BUS	:03		1	OPERATE MANIPULATORS	
– UNFOLD & INSPECT BEAM	:20		2	OPERATE MANIPULATORS	
– ATTACH TO LONG. BEAMS	:15		2	AUTOMATIC WELD	
• INSTALL RCS & SOLAR ARRAY	(3:00)	IVA		OPERATE MANIPULATOR	
– INSTALL RCS (2)	1:40		2		
– INSTALL S/A BRACE W/BUS	:10		2		
– INSTALL S/A	:50		2		
– DEPLOY S/A	:10		1		
– ATTACH SUBSYS BUSSES TO END BEAM BUS	:10		1		
• INSTALL ANTENNAS (2)	(1:48)	IVA			
– MOUNT ANTENNAS 50	1:40		2		
– DEPLOY ANTENNAS	:08		1		1 EM, 1-12[illegible]
• INDEX & ATTACH LATERAL BEAMS (9)	(7:12)	IVA			
– INDEX STRUCTURE	1:30		3	CONTROL ABM MOVEMENT	
– DEPLOY & ATTACH LONG BUS				OPERATE MANIPULATOR	REPEAT 9 TIMES
– DETACH & TRANSLATE BEAM W/BUS	:27		1		
– UNFOLD & INSPECT BEAM	3:00		2		
– ATTACH TO LONG BEAMS	2:15		2		
• INSTALL ANTENNAS & STAB. PACKAGE	(12:34)	IVA			
– INSTALL ANTENNAS (13)	10:50		2	OPERATE MANIPULATOR	
– DEPLOY ANTENNAS (13)	:54		1		
– MOUNT STABILIZATION UNIT	:50		2		

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Fig. 4.17-2 C4—Func: .ns, Time, & Tasks

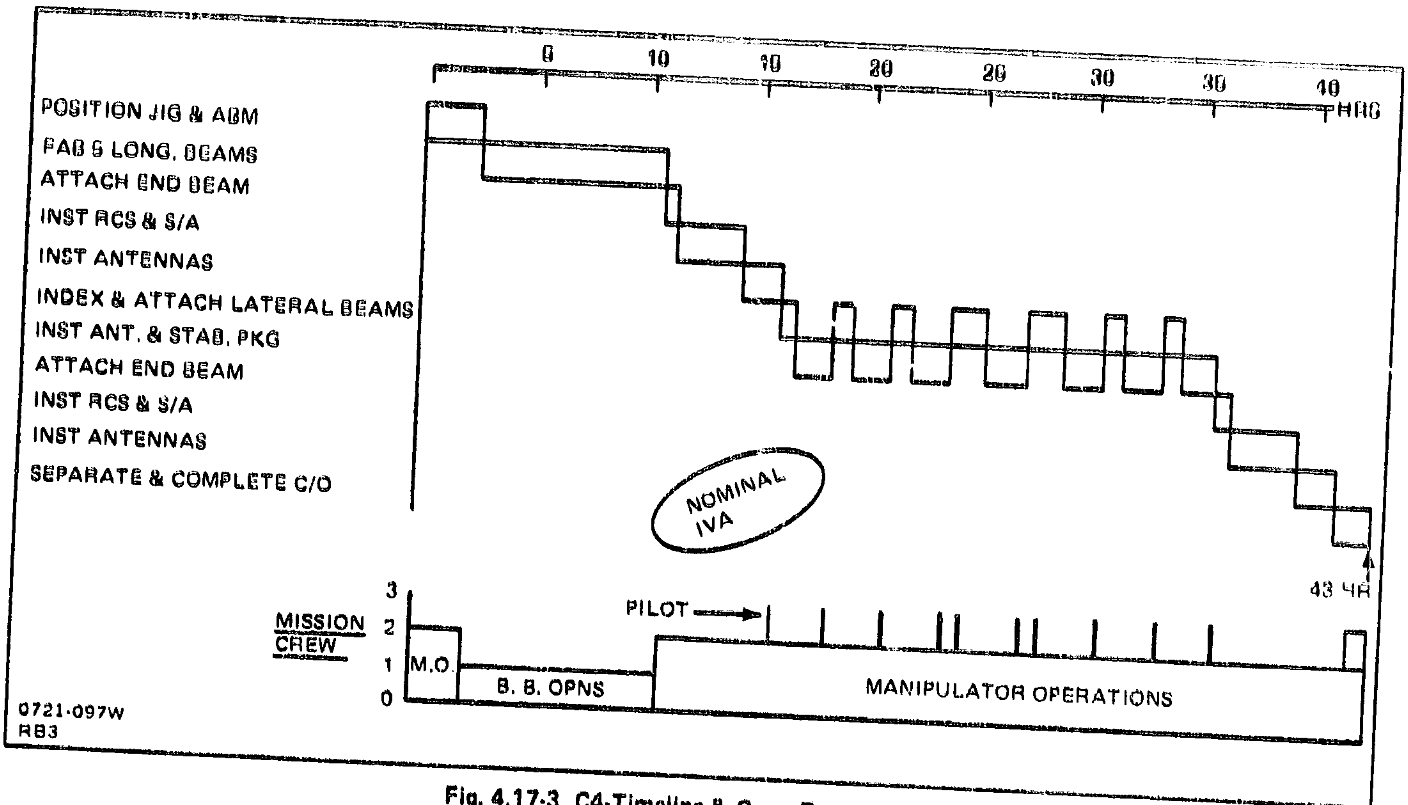
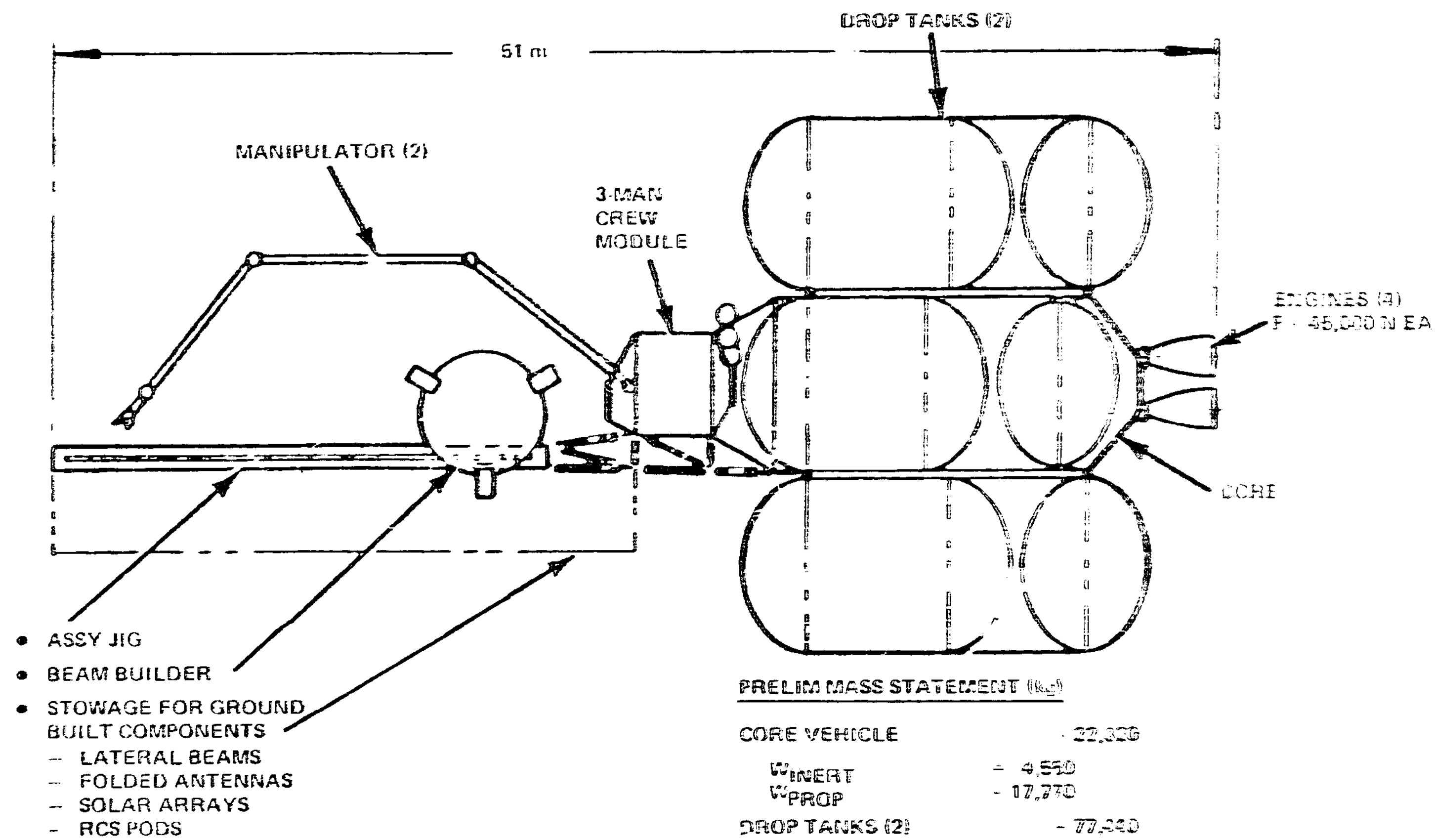


Fig. 4.17-3 C4-Timeline & Crew Requirements



PRELIM MASS STATEMENT (kg)

CORE VEHICLE		- 22,320
W_{INERT}	= 4,550	
W_{PROP}	- 17,770	
DROP TANKS (2)		- 77,440
W_{INERT}	= 4,840	
W_{PROP}	= 72,600	
PAYLOAD LAUNCHED		- 20,236
ROUNDTRIP	= 5,236	
DEPLOYED ONLY	- 15,000	
		119,996 kg

∴ REQUIRES 4 AVG STS LAUNCHES

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Fig. 4.17-4 C4 – MOTV LAUNCH CONFIGURATION

4.18 GENERIC MISSION C5 - CONSTRUCTION OF AN EARLY SOLAR POWER DEVELOPMENT ARTICLE (SPDA) TO PROMOTE MPTS TECHNOLOGY

Mission Description: An early SPDA is constructed in GEO, which has a full scale microwave antenna subarray that can transmit up to maximum power density to the ground. The integrated satellite is complete with power source, stabilization and control and translational station-keeping capability. The solar array which has a power output of approximately 14 MW (200M x 400M area) is constructed using autofab (beam builder) techniques as is the main structural members of the antenna. Once the array and antenna constructions are complete, they are joined together through a rotary joint. Subsystem integrated electronics and RCS for station keeping are then attached to form an operational satellite. Before MOTV departure back to earth the entire satellite is given a complete checkout to make sure everything is operating properly. The figure shows the SPDA in its operational configuration.

Characteristics:

Weight. . . . . 110,535 kg

Size

Length. . . . . 200 m

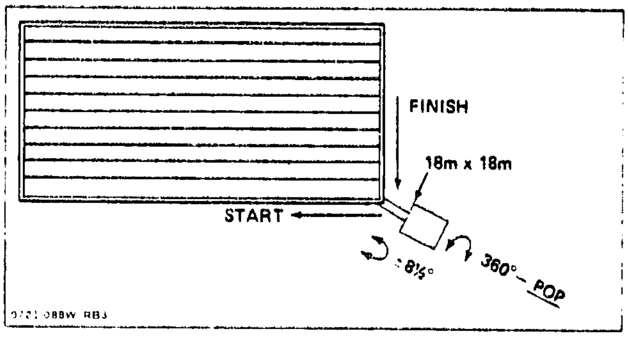
Width . . . . 400 M

Power . . . . 14 MW

Orbit . . . . GEO

Timeframe. 1990

Life/Serving Period . . . . 10/1 yr



Rationale for MOTV use:

- Same as Generic Mission C3.

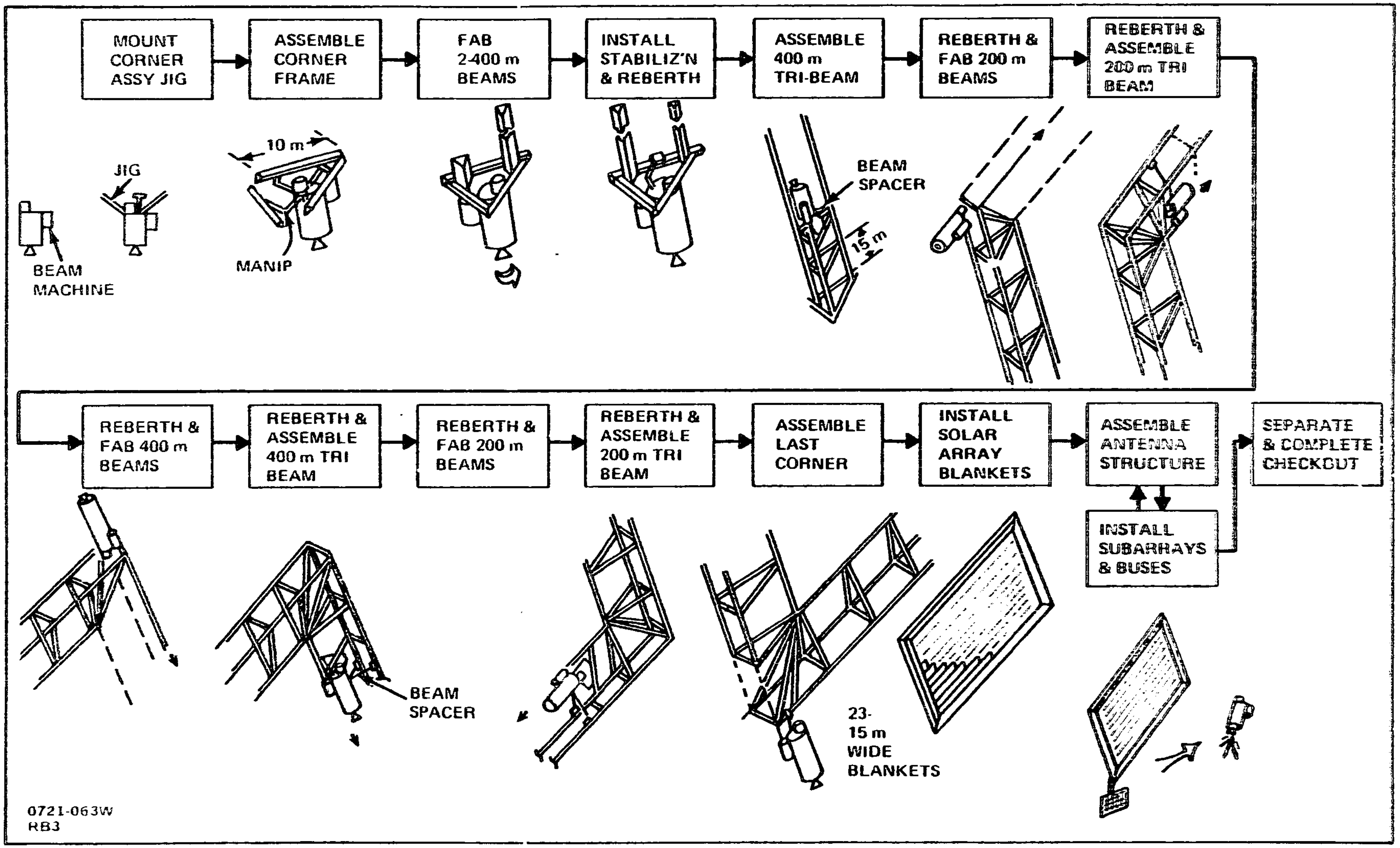


Fig. 4.18-1 C5-Assemble 14 MW Solar Power Development Article

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• MOUNT CORNER ASSY JIG	(:20)	IVA			
– ACTIVATE & POSITION MANIPULATORS	:10				
– CHECKOUT ASSY JIG STATUS	:05				
– REPOSITION JIG FOR USE	:05				
• ASSEMBLE CORNER FRAME	(:40)				
– UNCOVER & INSPECT PREFAB BEAMS	:05				3 BEAMS ASSUME FIXED JOINT
– UNSTOW & MOVE BEAMS TO JIG	:10				
– FASTEN BEAM END FITTINGS	:20				
– ADJUST JIG FOR LONG. BEAM FAB	:05				
• FAB 400 m BEAMS	(13:45)				
– ACTIVATE & CHECKOUT BEAM MACHINE	:05				
– ALIGN BEAM MACHINE FOR FAB	:05				
– FAB 1ST 400 m BEAM (~1m/min)	6:40			CONTROL FAB RATE	
– FASTEN BEAM TO END FRAME	:05				5 MIN
– REPOSITION & ALIGN FOR 2ND BEAM FAB	:05				
– FAB 2ND 400 m BEAM (~1 m/min)	6:40				
– FASTEN BEAM TO END FRAME	:05				
• INSTALL STABILIZATION & REBERTH	(1:10)				
– UNSTOW, INSTALL & C/O STAB. CTL MODULE	:50				
– SAFE/STOW ASSY JIG	:05				
– MANEUVER & BERTH TO OPPOSITE SIDE OF FRAME	:15				
• ASSEMBLE 400 m TRI BEAM	(18:50)	IVA			
– POSITION INDEXING BEAM SPACER	:05				
– ALIGN BEAM MACHINE FOR FAB	:05				
– FAB 3RD BEAM INCREMENTALLY & ATTACH	6:40				1 MIN/METER
– UNNEST & JOIN 81 DIXIE CUP STRUTS	((2:40))*		} 1	MONITOR & CONTROL AUTOMATIC OPERATION	*2 MIN EACH PARALLEL WITH FAB
– TRANSLATE & ALIGN 81 STRUTS	4:00		} 2		3 MIN EACH
– ADJUST & FASTEN 81 STRUTS	6:45				5 MIN EACH
– TRANSLATE & INSTALL CORNER DIAG	:25				3 BEAMS 8 MIN EACH
– INSTALL DATA BUS	–		} 1		PARALLEL WITH
– INSTALL POWER BUS	–				FAB
– INSTALL RCS	:50				
• REBERTH & FAB 200m BEAMS	(7:25)	IVA			
– SAFE/STOW BEAM SPACER & BEAM MACH	:10				
– MANEUVER & BERTH FOR FAB	:15		1		
– ALIGN BEAM MACH	:05				
– FAB 1ST 200m BEAM (1 MIN/m)	3:20		1		

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Fig. 4.18-2 C5-Functions, Time, & Tasks

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
– FASTEN BEAM TO CORNER MEMBER	:05				
– REPOSITION & ALIGN FOR 2 ND BEAM	:05				
– FAB 2ND 200m BEAM	3:20		1		
– FASTEN BEAM TO CORNER MEMBER	:05				
• REBERTH & ASSEMBLE 200m TRI BEAM	(10:20)				
– RELEASE, MANEUVER & REBERTH FOR FAB	:25				
– POSITION INDEXING BEAM SPACER	:05				
– ALIGN BEAM MACHINE	:05				
– FAB 3RD BEAM INCREMENTALLY & ATTACH	3:20				
– UNNEST & JOIN 39 DIXIE CUP STRUTS	1:20				2 MIN EA
– TRANSLATE, ALIGN, ADJUST & FASTEN 39 STRUTS	5:10				8 MIN EA
– INSTALL BUSES (DATA & PWR)	–				PARALLELS FAB
– INSTALL RCS	:50				
– TRANSLATE & INSTALL CORNER DIAG	:25				3 BEAMS @ 8 MIN EA
• REBERTH & FAB 400 m BEAMS	(14:05)				
– SAFE/STOW BEAM SPACER & BEAM MACHINE – MANEUVER & BERTH FOR FAB	:25				
– ALIGN BEAM MACHINE FOR FAB – FAB 1ST 400 m BEAM – FASTEN BEAM TO CORNER MEMBER – REPOSITION – FAB 2ND BEAM – FASTEN 2ND BEAM TO CORNER MEMBER	13:40				
• REBERTH & ASSEMBLE 400 m TRI BEAM	(19:15)				
– RELEASE MANEUVER & REBERTH FOR FAB	:25				
– ASSEMBLE 400 TRI BEAM AS ABOVE	18:50				
• REBERTH & FAB 200 m BEAMS AS ABOVE	(7:25)	IVA			
• REBERTH & ASSEMBLE 200 m TRI BEAM AS ABOVE	(10:20)	IVA			
• ASSEMBLE LAST CORNER	(1:25)				
– SAFE/STOW BEAM SPACER & BEAM MACHINE – RELEASE, MANEUVER, REBERTH & ALIGN FOR FAB	:30				
– FAB & ATTACH 1ST 15 m LONG BEAM	:25				1 MIN/METER & 5 MIN EACH ATTACHMENT
– REPOSITION	:05				
– FAB & ATTACH 2ND 15 m LONG BEAM	:25				

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Fig. 4.18-2 C5-Functions, Time, & Tasks (contd)

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• INSTALL SOLAR ARRAY BLANKETS	(56:50)	IVA			
– MANEUVER & REBERTH ON 1ST 200 m LEG	:10				
– ATTACH LATERAL INDEXING DEVICE	1:30				3 TIMES @ 30 MIN EACH
– UNSTOW TRANSLATE & INSTALL 23 S/A MODULES	19:10		2	OPERATE MANIP	50 MIN/MODULE
1ST 200 m LATERAL INDEX	3:20			ROUTE S/A DEPLOYMENT CABLES	1 MIN/METER
– 400 m LATERAL INDEX	6:40				
– 2ND 200 m LATERAL INDEX	3:20				
– INSTALL S/A DEPLOYMENT MOTORS	19:10			INSTALL MOTOR & ATTACH S/A CABLE	50 MIN PER
– DEPLOY SOLAR ARRAYS & C/O	3:30				400 m @ 1 MIN/2 m + 10 C/O
• ASSEMBLE ANTENNA STRUCTURE	(2:00)				
– UNSTOW, TRANSLATE & INSTALL 12 m MAST	:50				TREAT LIKE MODULES
– UNSTOW TRANSLATE & INSTALL FOLDED ANTENNA FRAME	:50				
– DEPLOY & INSPECT 18 m x 18 m FRAME	:20				
• INSTALL ANTENNA SUBARRAYS & BUSES	(12:10)			OPERATE MANIP TO POSITION BUS & INSTALL STANDOFFS	
– INSTALL & C/O ANTENNA POWER BUS	1:05				2 x 13 STANDOFFS 5 MIN INSTALL TIME FOR 2 STANDOFFS
– INSTALL & C/O ANTENNA DATA BUS	1:05				
– INSTALL 12.9 m x 3 m ANTENNA SUBARRAYS	10:00				
• SEPARATE & COMPLETE CHECKOUT	(1:20)				
– SAFE/STOW MANIPULATORS	:10				
– SAFE/STOW INDEXING DEVICE	:05				
– RELEASE BERTHING DEVICE	:30				
– MANEUVER TO VERIFY SPDA CONFIG					
– SUPPORT PLATFORM SPACE GROUND C/O	:35				

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Fig. 4.18-2 C5-Functions, Time, & Tasks (contd)

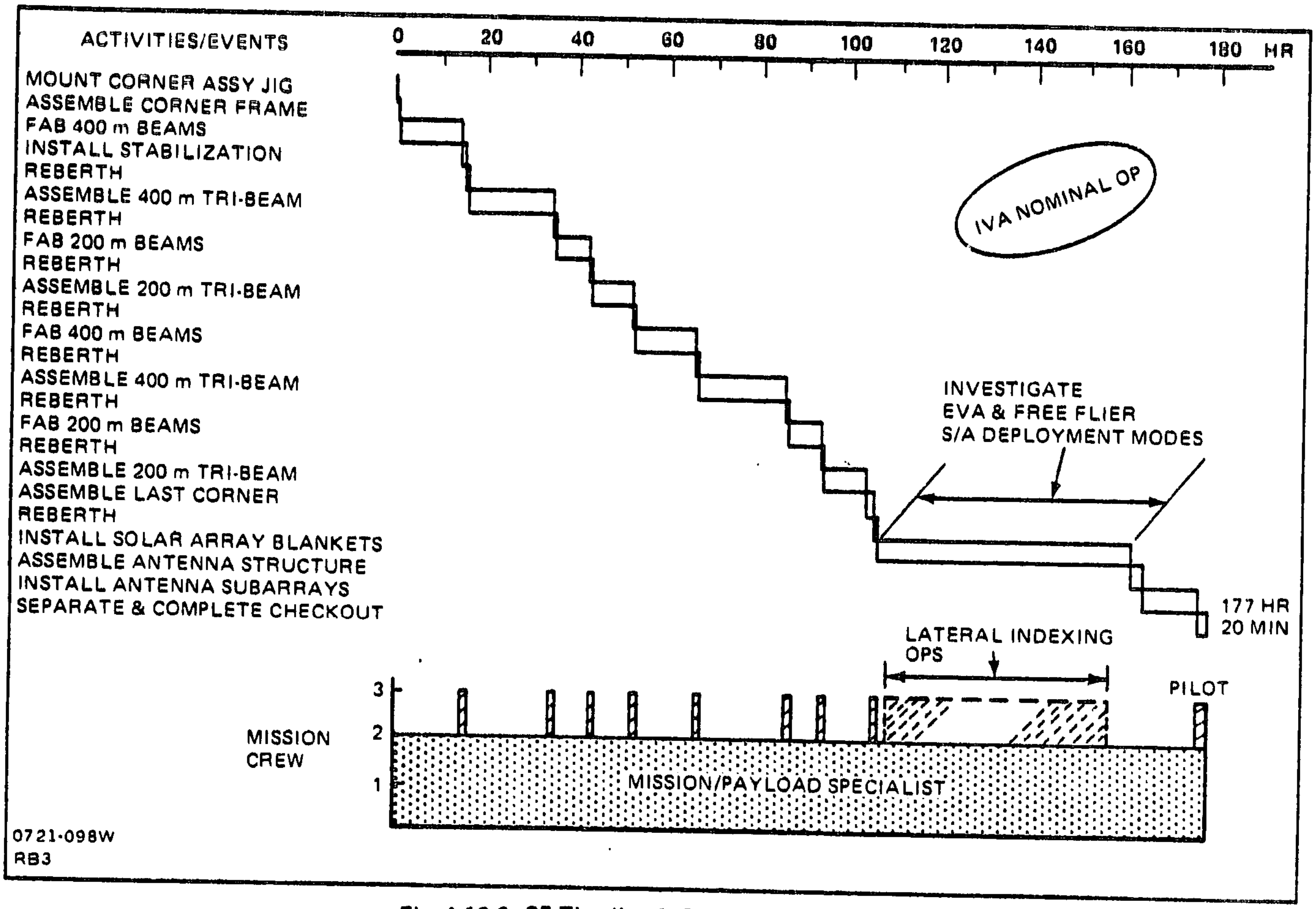

Fig. 4.18-3 C5-Timeline & Crew Requirements

MOTV PAYLOAD WEIGHT-TO-ORBIT					
WEIGHT ITEM	TOTAL WT. (kg)	FLIGHT NO. 1 (kg)	FLIGHT NO. 2 (kg)	FLIGHT NO. 3 (kg)	FLIGHT NO. 4 (kg)
• MISSION HARDWARE	(110,535)	23,841	28,898	28,898	28,898
– S/A BLANKET	71,093	7,400	21,231	21,231	21,231
– STRUCTURE	13,781	13,781	–	–	–
– MAST	1,276	1,276	–	–	–
– ANT. SUBARRAY	24,385	1,384	7,667	7,667	7,667
• CREW MODULE	4,448	4,448	4,448	4,448	4,448
• DOCKING ADAPTER	(408)	(408)	(408)	(408)	(408)
• ON-ORBIT MISSION EQUIP.	8,722	8,722	1,097	1,097	1,097
– MANIPULATORS	474	474	474	474	474
– FIXTURES/JIGS	100	100	–	–	–
– BEAM BUILDER	7,500	7,500	–	–	–
– CONST TOOLS	25	25	–	–	–
– MMUs	270	270	270	270	270
– EVA SUITS	283	283	283	283	283
– CALIB & C/O EQUIP	10	10	10	10	10
– SPARE PARTS	40	40	40	40	40
– EQUIP. STOWAGE RACKS	20	20	20	20	20
TOTAL	124,113	37,419	34,851	34,851	34,851

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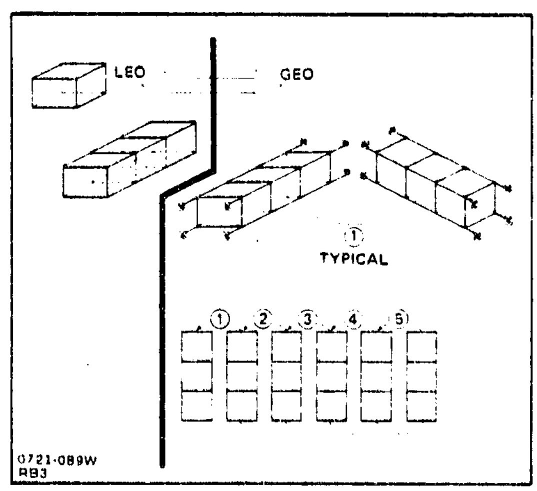
Fig. 4.18-4 Construction Mission C5-Flight Analysis

4.19 GENERIC MISSION C6 - MODULAR ASSEMBLY OF A 60 MW SPDA

Mission Description: A large solar power development article shown in figure below is constructed and partially assembled in LEO. The modular assemblies, each three-bays wide, are then transported to GEO via a cargo OTV (COTV) to await final assembly by the MOTV. Once all six modules are in GEO, separated from each other at a safe distance of approximately 50 n mi, the MOTV is dispatched to oversee the final phasing, docking and assembly of modules. It is assumed that the phasing and docking maneuvers, module-to-module, are performed by the COTV thrusters, but controlled from the MOTV. This may be accomplished with the MOTV berthed to one of the modules or accomplished through a remote data link to the MOTV "standing-off" a short distance from both modules. Once docking is complete the MOTV crew would then begin the process of connecting the remaining hardpoints together. A short time prior to completion of this task another module is commanded to phase and rendezvous with the new assembly. Since these phasing maneuvers may take up to a day to complete it saves time to begin them somewhat prior to completion of the previous assembly tasks. This sequence is repeated five times after which final checkout is performed. In the entire assembly process it is presumed that the microwave antenna is part of one of the modules assembled in LEO.

Characteristics:

Weight	800,000 kg
Size	
Length	450 m
Width	900 m
Power	60 MW
Orbit	GEO
Timeframe	Mid 90s
Life/Servicing Period	30/3 yr



Rationale for MOTV Use:

- This mission is a forerunner to full scale SPS construction and assembly. It is an end-to-end demonstration, on a reasonable subscale basis, to verify that a solar power satellite can be built and operated in GEO. Man's involvement here is typical of that which is expected for the full scale SPS.
- On-orbit crew participation in joining large structural modules together is an integral part of this end-to-end demonstration.

- Performing the unfold/assembly and checkout operations in the final orbit (GEO) rather then LEO has the following benefits:
  - Provides constant thermal environment which avoids the day/night cycles in LEO
  - Failure to deploy due to differential expansion is minimized
  - Manned supervised checkout and rectification is done in proper orbit which avoids the need of high slew rates that are required for LEO checkout.

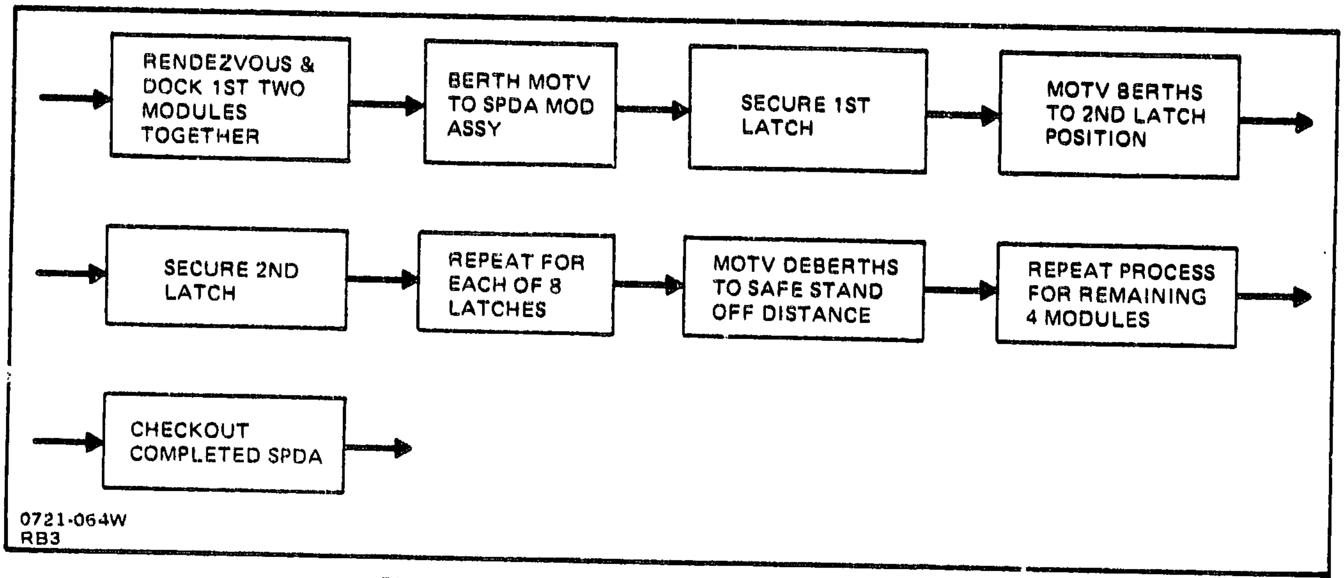


Fig. 4.19-1 C6-Modular Assembly of a 60 MW SPDA

ACTIVITY/FUNCTION	TIME HR: MIN	CREW MODE	NO. CREW	CREW TASK	REMARKS
• RENDEZVOUS & DOCK 1ST TWO SPDA MODULES TOGETHER	24:00	IVA	2		
• BERTH MOTV TO SPDA MODULAR ASSY	1:00	IVA	2		
• SECURE 1ST LATCH USING MOTV MANIPS	1:00	IVA	1		
• REBERTH TO 2ND LATCH POSITION	1:00	IVA	2		
• SECURE 2ND LATCH	1:00	IVA	1		
• REPEAT STEPS 4 & 5 SIX MORE TIMES	12:00	IVA	2		
• DEBERTH MOTV TO SAFE STANDOFF DISTANCE	1:00	IVA	2		
• REPEAT STEPS 1 THRU 7 FOUR MORE TIMES SECURE EACH OF THE REMAINING SPDA MODULES IN A SIMILAR FASHION	164:00	IVA	2		
• CHECKOUT COMPLETED SPDA ASSY	2:00	IVA	2		
TOTAL	207:00				

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Fig. 4.19-2 C6-Functions, Times, & Tasks

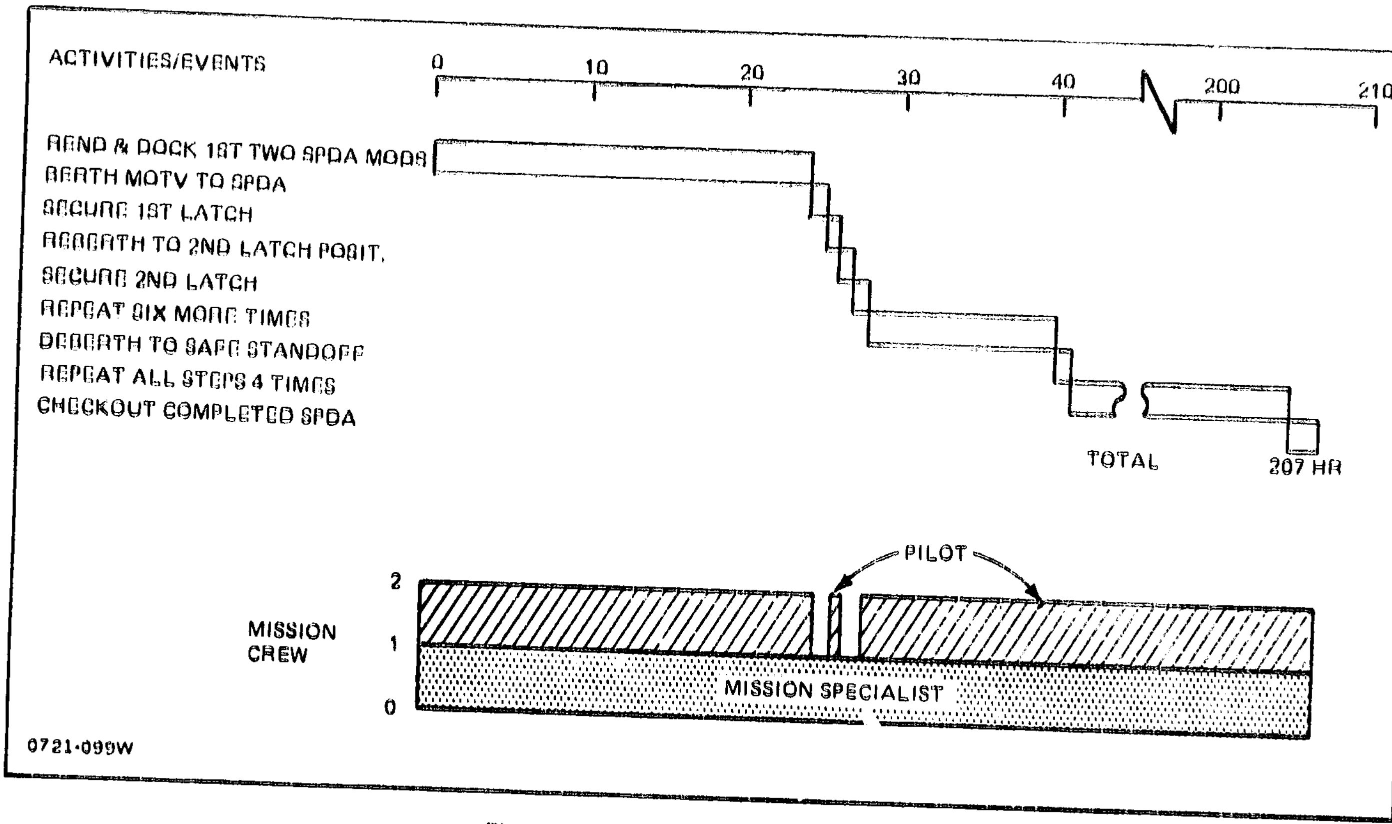

Fig. 4.19-3 C6-Timeline & Crew Requirements

	CREW CAPSULE	PROP'LS'N CORE	DROP TANKS (2)	MISSION EQUIP'T GENERAL PURPOSE	MISSION EQUIP'T DEDICATED
DRY WEIGHT	3766	3299	2950	816	0
CREW/CONSUMABLES RESERVES/RESIDS	382	61 296	470		
BURNOUT WEIGHT	4147	3646	3420	816	0
MAIN PROP – (CAPACITY) – LOADING ACPS PROP MISC		(17,500) 15,881 2467 146	(54,540) 44,930		
MOTV WEIGHT	4147	22,150	48,360	816	0
TOTAL MOTV WEIGHT	75,472				

1776-437W

Fig. 4.19-4 Construction C6 Summary Wt Statement, kg

CREW CAPSULE		WEIGHT, kg
STRUCTURE		1516
THERMAL PROT		48
EPS		26
AVIONICS		149
ECLS		511
CREW ACCOM		758
PROPULSION		6
RECOVERY		—
CONTINGENCY	(25%)	753
TOTAL DRY WEIGHT		3766
CREW	(2)	163
CONSUMABLES	(17 DAYS)	219
BURNOUT WEIGHT		4147

NOTES

- MANIPULATORS, ETC., CHARGED TO GEN PURPOSE MISSION EQUIP.
- EPS SUBSYS IS POWER DISTR. ONLY – REMAINDER OF SUBSYS IN PROP. CORE

1776-438W

Fig. 4.19-5 C6 Wt Statement (Crew Capsule)

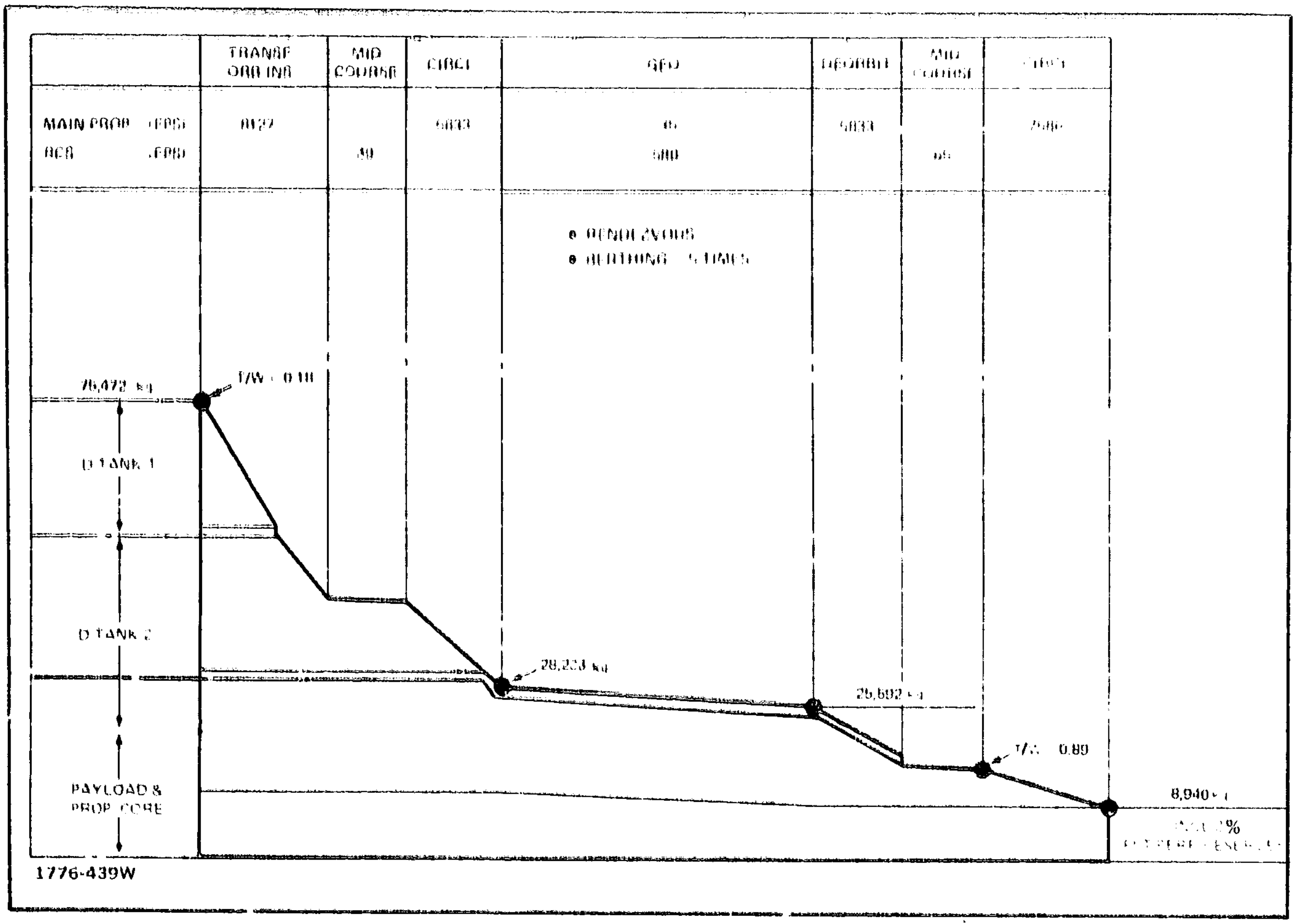

Fig. 4.19-6 Performance Data – Construction Mission (C6)

4.20 GENERIC MISSION UC - UNMANNED CARGO TRANSPORT 10,000-100,000 kg TO VARIOUS ORBITS

Mission Description: The MOTV is used in an unmanned mode to transfer various sized cargos from LEO to high earth orbits not attainable with the Shuttle and IUS. The propulsive capability of the MOTV to transfer these payloads to orbits ranging from 1500 nmi and high inclination to GEO, or LEO or escape will be defined.

Characteristics:

Weight	5000 - 50,000 kg
Size	NA
Power	NA
Orbit	Various
Timeframe	1980-2000
Life/Servicing Period . .	NA

Rationale for MOTV Use:

- Outside the payload capability of Shuttle/IUS system
- Lower transport g's than IUS
- Available assuming manned version is adapted.

5 – Turnaround Analysis

Development of a routine turnaround process is required in order to employ the MOTV to enhance man's utilization of the geosynchronous space region. Since turnaround operations represent approximately 70% of the total MOTV mission, the process necessary to check, restore and prepare the returning MOTV for its next mission should be analyzed and optimized to provide a reliable low cost turnaround program.

A definition of the turnaround requirements for the design reference mission (DRM), S-1, MOTV configuration and an analysis of the primary sensitivity issues indicate the following:

- The MOTV is a fairly sophisticated spacecraft with man-rated systems, including two RL10 II B engines, an attitude control and stabilization system, a full complement of avionics and satellite servicing equipment.
- A routine cost effective turnaround plan must make maximum use of flight data for maintenance planning, a high degree of test automation and MOTV maintainability features in order to minimize tests, facilitate repair and reduce the manpower requirements.
- Dollars spent on an effective turnaround maintenance program restore the returning MOTV hardware reliability to the design goals, providing a payback in terms of reduced risk.

The turnaround/maintenance analysis discussed in detail in Volume 5 of this report, entitled "MOTV Turnaround Analysis" indicates the following:

- The recommended turnaround scenario baselines ground turnaround because it utilizes in place facilities, has the flexibility to deal with contingencies which will occur during the operational shakedown period and provides a benign environment in which to gain experience, work out procedures, and refine support equipment requirements.
- SOC turnaround at 200 N MI provides a viable alternate because it decouples the turnaround operations from the STS support flights and saves approximately $11M per mission. SOC turnaround, however, requires a significant

investment in facilities, support equipment and MOTV maintainability features, approximately \$330M. Payback takes about 15 years, assuming an MOTV flight rate of 6/year. The SOC option should be retained until the appropriate program milestone, when the following can be resolved.

- SOC operational attitude lowered to 200 NM rather than the current assumption of 265 N MI.
- Definitive costs obtained for facility, MOTV design, and support equipment costs.
- An assessment of the portion of the initial investment for facilities which are chargeable to institutional improvements or other programs rather than MOTV.

If the decision at the appropriate program milestone is to proceed with SOC, then a progressive program which transitions from ground turnaround to STS tended LEO turnaround, which would qualify and refine the SOC equipment, procedures and personnel to the final phase utilizing SOC is recommended.

6 - SUPPORTING STUDIES

This section contains supporting analysis relavent to mission modes selection, MOTV performance, IVA/EVA trades, crew capsule sizing and unmanned OTV payload performance. It serves as the basis for selecting various modes of operation for the MOTV and permits consideration off-design alternates.

• 1½ STAGE CONCEPTS	HIGHEST PERFORMANCE
• AMOTV & AMRV	HIGHEST PERFORMANCE FOR "ROUND TRIP" PAYLOADS – BUT RETURN OF BULKY PAYLOADS IS QUESTIONABLE WITH THESE MODES
• APOTV, AMOTV, & AMRV	EQUAL PERFORMANCE FOR "HEAVY UP – LIGHT BACK" PAYLOADS
• SINGLE LAUNCH/MISSION	MODEST PERFORMANCE USING AUGMENTED STS & HIGH PERFORMANCE ENGINES – LOW MARGINS
• MULTI LAUNCH/MISSION	AMPLE PERFORMANCE – HIGHER COST PER MISSION
• LEO TURNAROUND (USING STS ONLY)	NOT COST BENEFICIAL
• LEO TURNAROUND (USING MANNED DEPOT)	MAY BE WORTHWHILE WITH EVENTUAL HEAVY TRAFFIC

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Fig. 6-1 Mission Mode Findings – First 3 Mo.

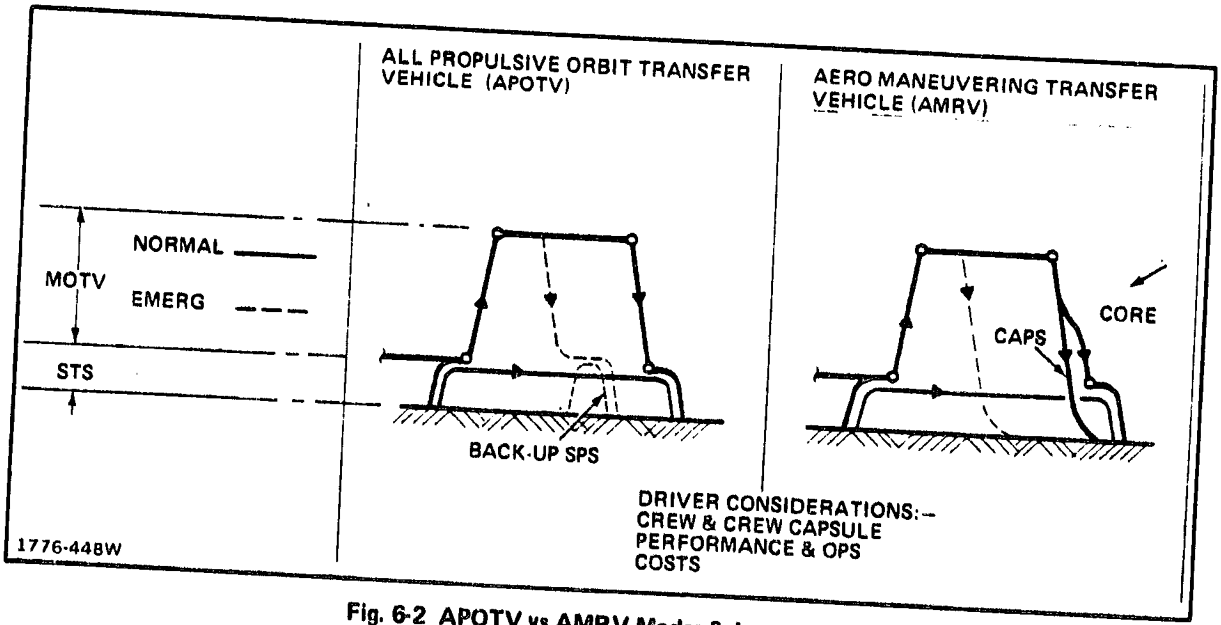

Fig. 6-2 APOTV vs AMRV Modes & Issues

ENTRY MODE	APOTV		AMRV		
CAPSULE VOL.	$10.6\ m^3$	$26\ m^3$	$11.5\ m^3$	$26\ m^3$	AMRV WEIGHTS DIFFER FROM APOTV WEIGHTS BECAUSE:
STRUCT	856	1628	565	1055	LESS RAD. PROTECT.NEEDED
TPS	—	—	720	1202	ENTRY HEATING
EPS	56	60	76	80	SOLO PWR SUPPLY (4 Kw Hr)
AVIONICS	140	140	255	255	FULL GN&C AND COMM
ECLS	258	274	297	315	ENTRY HEAT SINK
CREW ACCOM	418	.704	502	798	HIGH 'G' COUCHES
RCS			90	108	FULL SUBSYST.
RECOVERY			478	638	CHUTES/RETRO SRM/LND GR.
CONTINGENCY	173	281	298	445	
TOTAL DRY	1901	3087	3281	4896	
CREW	163	163	163	163	
CONSUMABLES	95	176	113	196	RCS PROPELLANT
CAPSULE	2159	3426	3557	5255	1776-449W

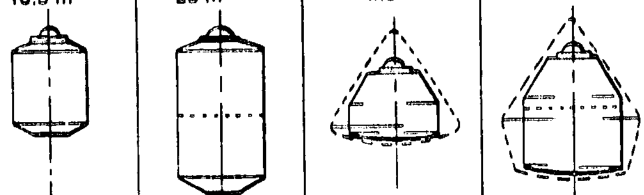

Fig. 6-3 Typical Crew Capsule Wts

	APOTV	AMRV
• CREW CAPSULE		LESS ROOM IN FLIGHT DECK & MANIPULATOR WORK STATION
• PERFORMANCE		GENERALLY 6% HIGHER STACK WEIGHT
• RETURN FLIGHT OPERATIONS	12/24 HR TO GROUND	MORE COMPLEX HIGHER ENTRY 'G' 7 HR TO GROUND
• DEVELOPMENT COST		15% HIGHER
• COST PER MISSION		10% HIGHER

RECOMMENDATION: IN PHASE 2 - CONCENTRATE ON ONE MISSION MODE

1776-450W

Fig. 6-4 APOTV vs AMRV Summary & Recommendations

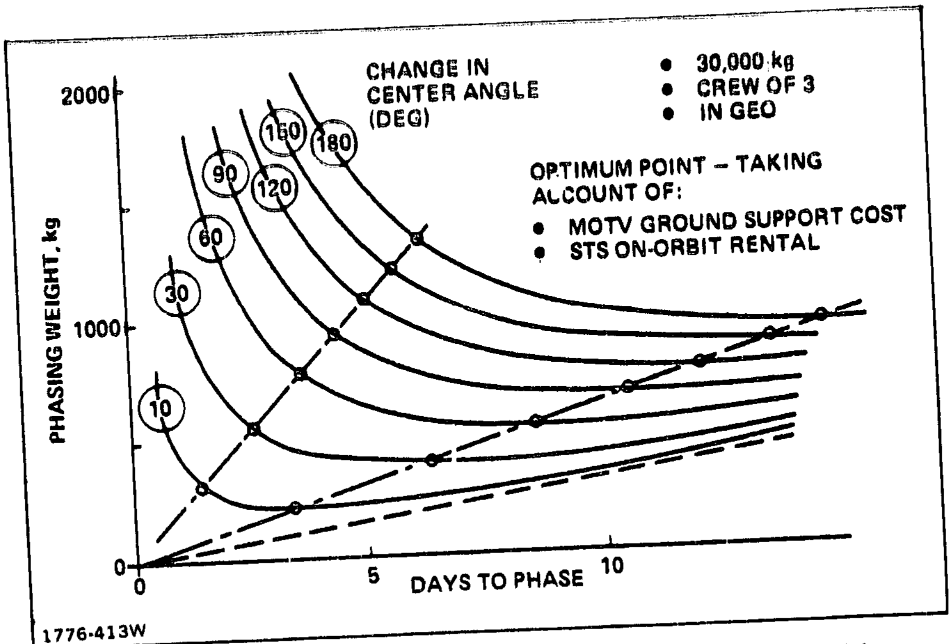

Fig. 6-5 Phasing Weight (Δ V PROPELLANT PLUS Food, Water, Atmos Make-up, RCS Prop.) vs Days to Phase

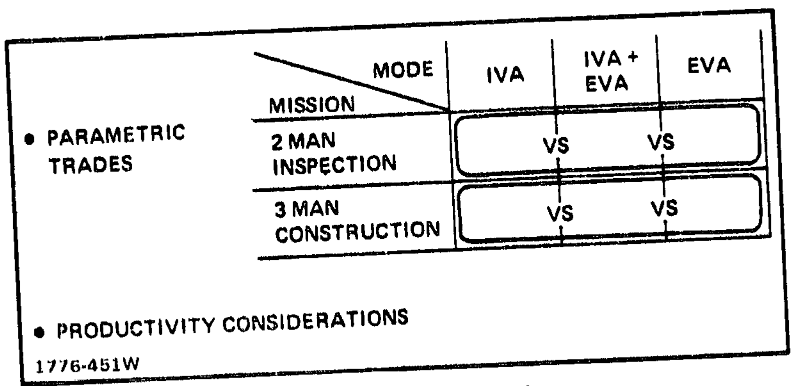

Fig. 6-6 IVA vs EVA Study

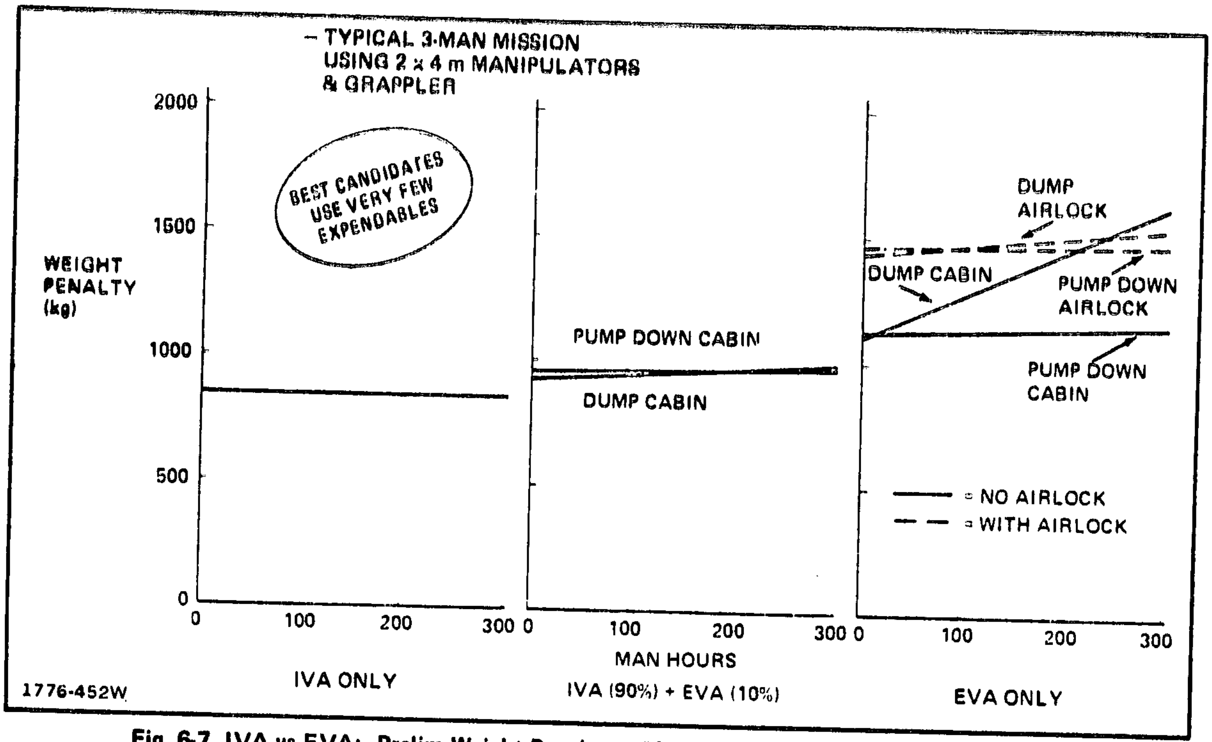

Fig. 6-7 IVA vs EVA: Prelim Weight Penalty vs Man Hours for 2-Man Inspection Mission

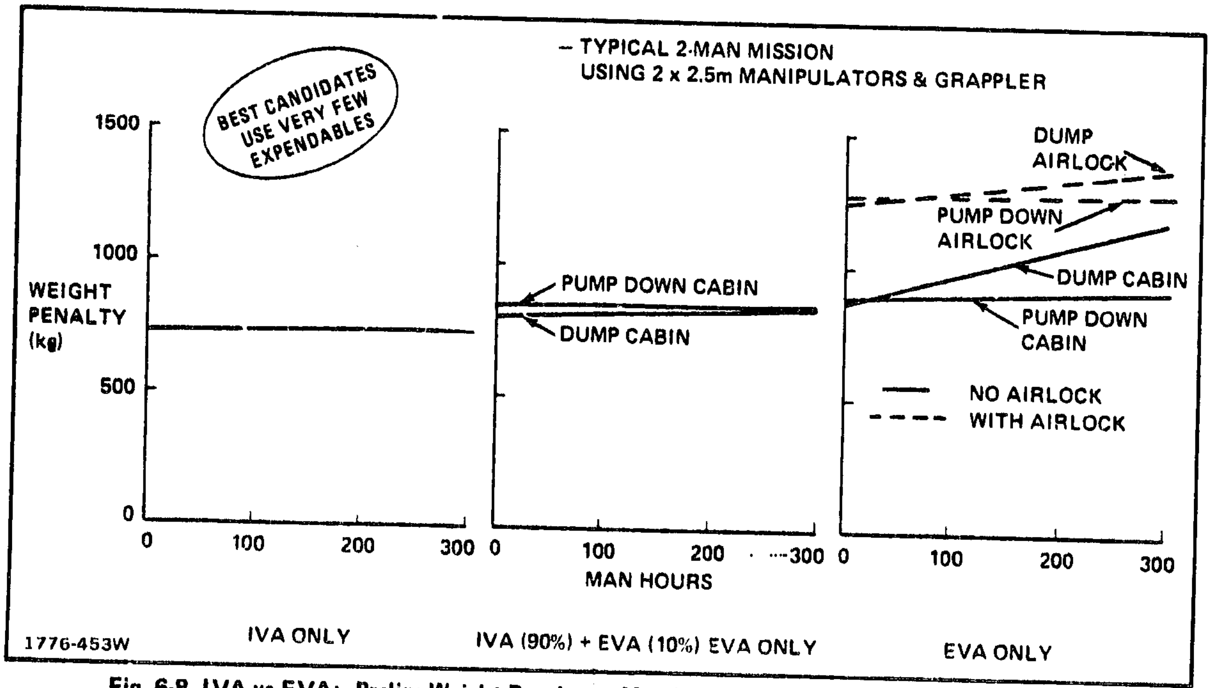

Fig. 6-8 IVA vs EVA: Prelim Weight Penalty vs Man Hours for 3-Man Construction Mission

	IVA ONLY	IVA (90%) + EVA (10%) -DUMP CABIN	EVA ONLY DUMP CABIN	EVA ONLY PUMP DN. CABIN
BASIC WEIGHTS (INCL EMERGENCIES)				
MANIPULATORS	390	390	–	–
GRAPPLER	60	60	60	60
OPEN CHERRY PICKER	–	–	340	340
VIEW DOME	20	20	–	–
TANTALUM SHIELD	–	–	140	140
GEO SUIT	–	324	324	324
LEO SUIT	258	–	–	–
ATMOSPHERE PUMP DOWN EQUIP.	–	–	–	33
EMERGENCY ATMOSPHERE	15	15	15	1
	733	799	869	888
EXPENDABLES PER WORK SHIFT				
ATMOSPHERE	–	15	15	1
1776-454W				

Fig. 6-9 IVA vs EVA: Detailed WT Penalties (kg) for Typical 2-Man Inspection/ Repair Mission

	IVA ONLY	IVA (90%) + EVA (10%) -DUMP CABIN	EVA ONLY DUMP CABIN	EVA ONLY PUMP DN. CABIN
BASIC WEIGHTS (INCL EMERGENCIES)				
MANIPULATORS	474	474	–	–
GRAPPLER	60	60	60	60
OPEN CHERRY PICKER	–	–	340	340
VIEW DOME	20	20	–	–
TANTALUM SHIELD	–	–	340	340
GEO SUIT	–	324	324	324
LEO SUIT	258	–	–	–
CABIN SUIT	8	8	8	8
ATMOSPHERE PUMP DOWN EQUIP	–	–	–	44
EMERGENCY ATMOSPHERE	37	37	37	2
	857	923	1109	1118
EXPENDABLES PER WORK SHIFT				
ATMOSPHERE	–	37	37	2
1776-455W				

Fig. 6-10 IVA vs EVA: Detialed WT Penalties (kg) for Typical 3-Man Construction Mission

- REPLACEMENT OF MMS-TYPE MODULES REPRESENTS A REALISTIC FUTURE TASK FOR GEO SERVICING
- MMS MODULE REPLACEMENT REQUIRES USE OF OCP. MMS UNITS ARE TOO LARGE TO HAND CARRY FROM MOTV STOWAGE AREA TO SATELLITE
- EVA EVENT TIMES ARE BASED ON NASA WATER TANK TESTS, SKYLAB, AND MRWS DATA
- IVA EVENT TIMES FOR MANIPULATOR OPERATIONS ARE BASED ON PRINCETON "TOKAMAK" AND LOS ALAMOS EXPERIENCE WITH THIS PARTICULAR MANIPULATOR SYSTEM

1776-456W

Fig. 6-11 Productivity Considerations – Groundrules & Assumptions

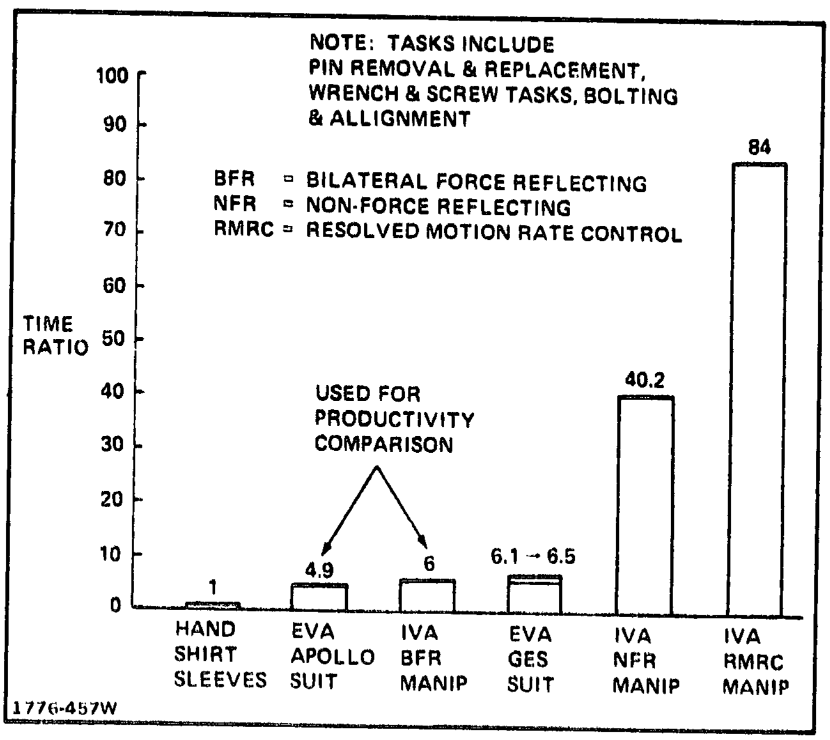

Fig. 6-12 Times to Perform Typical Space Tasks

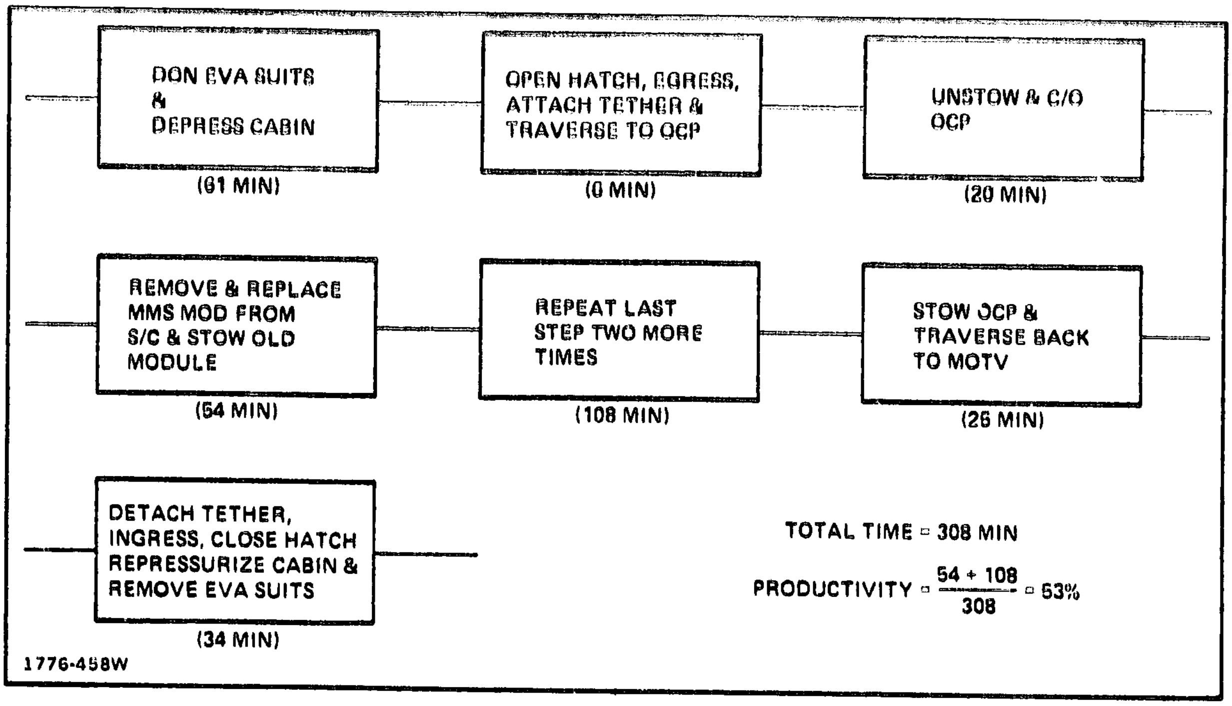

Fig. 6-13 EVA Events & Times to Service One MMS Type Satellite

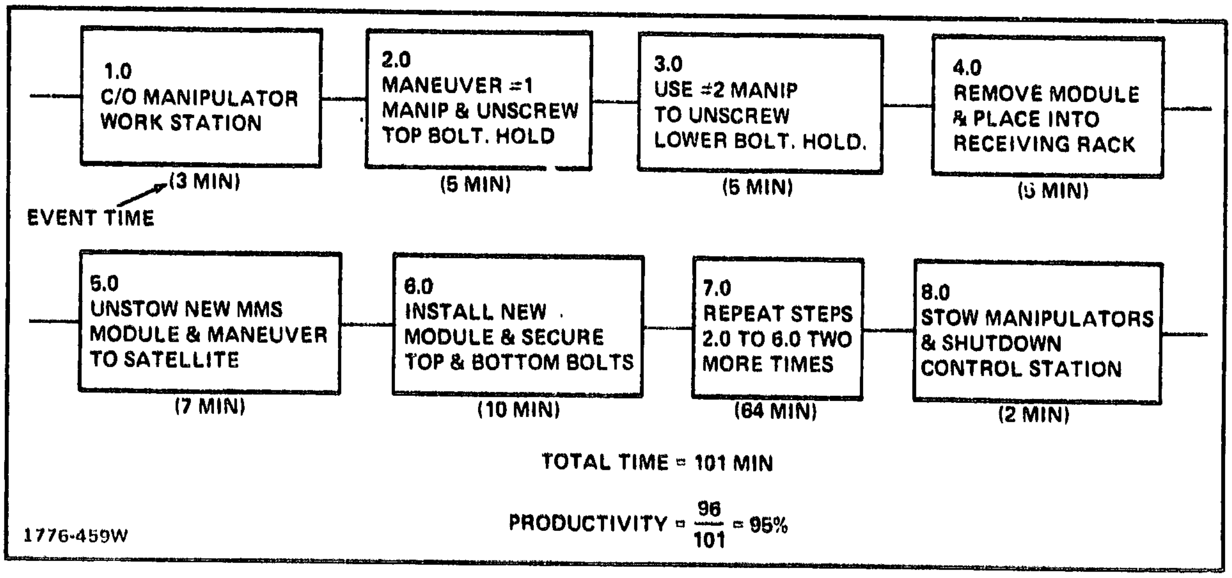

Fig. 6-14 IVA Events & Times to Service One MMS Type Satellite

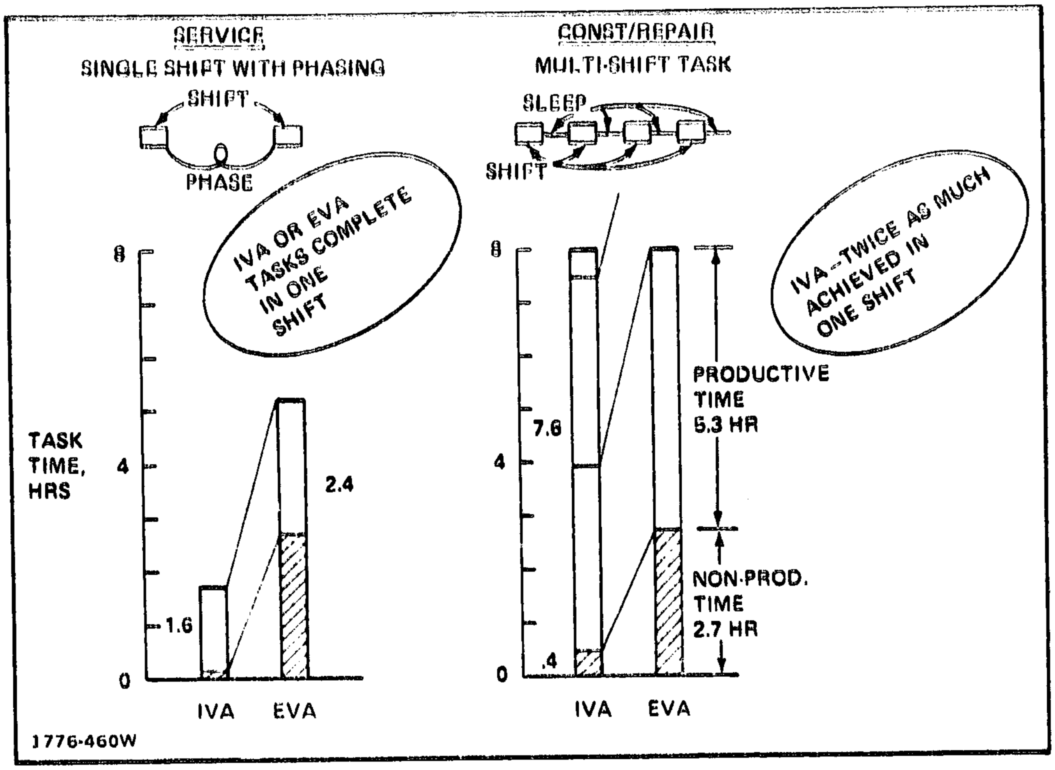

Fig. 6-15 IVA/EVA Productivity Comparison For 2 Types of Taks

- IVA FOR MOST ANTICIPATED TASKS
  - BFR MANIPULATORS
  - STABILIZER FOR BERTHING
- EVA FOR CONTINGENCY AND EMERGENCY OPERATIONS
  - LEO SUITS & TETHER (2 REQ'D)
  - IN-CABIN SUITS FOR 3RD CREWMAN
  - EVA TOOL KIT

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Fig. 6-16 IVA/EVA Recommendations

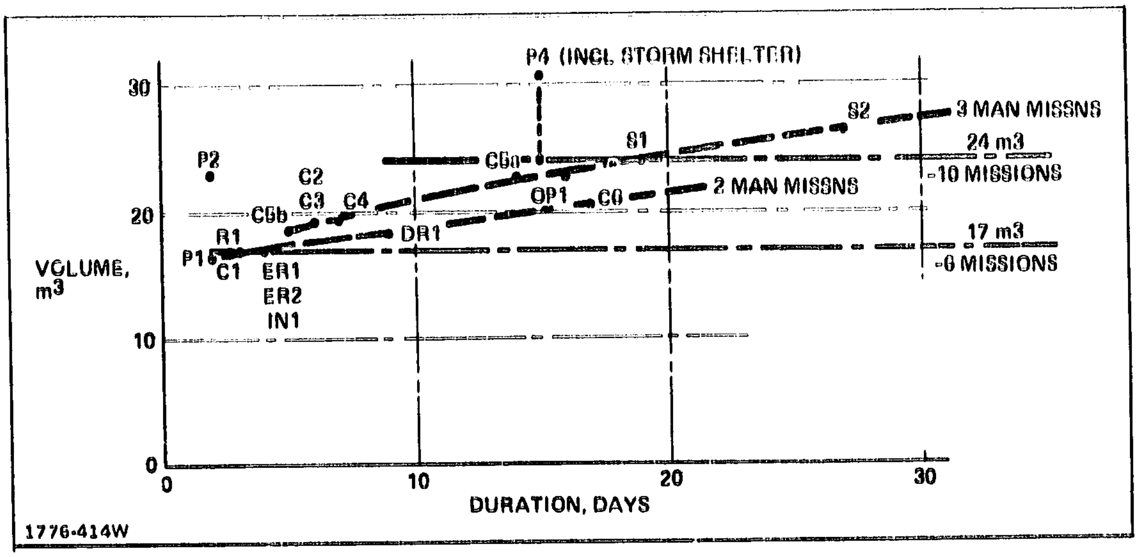

Fig. 6-17 Total Cabin Volume vs Duration for 17 Missions

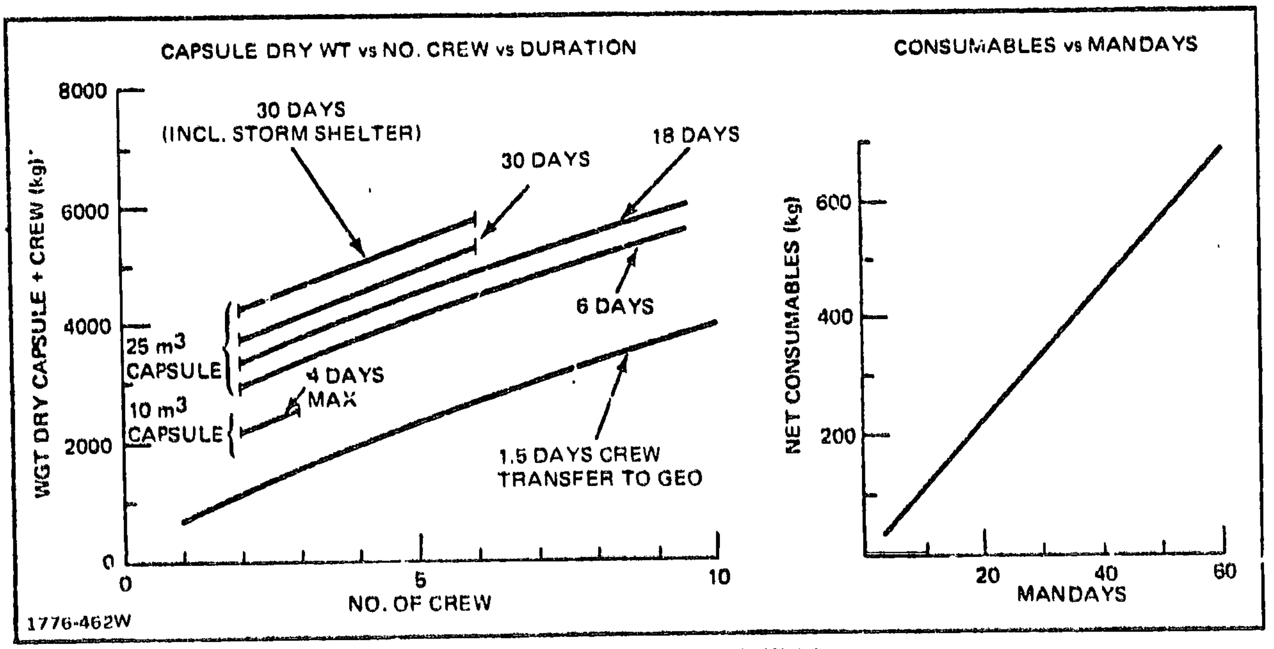

Fig. 6-18 Crew & Crew Capsule Weights

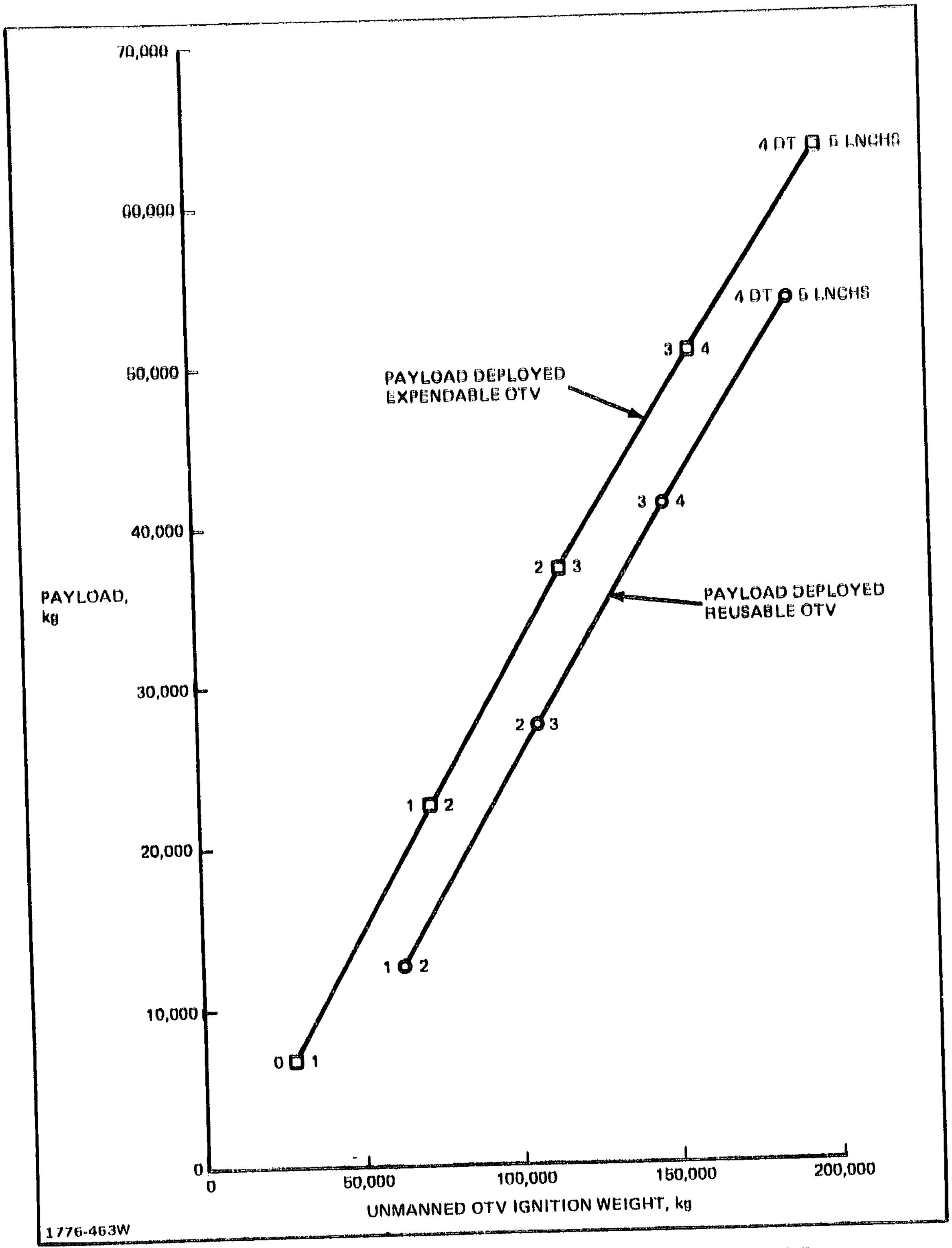

Fig. 6-19 Unmanned OTV Payload Capability for Payload Loitering in LEO

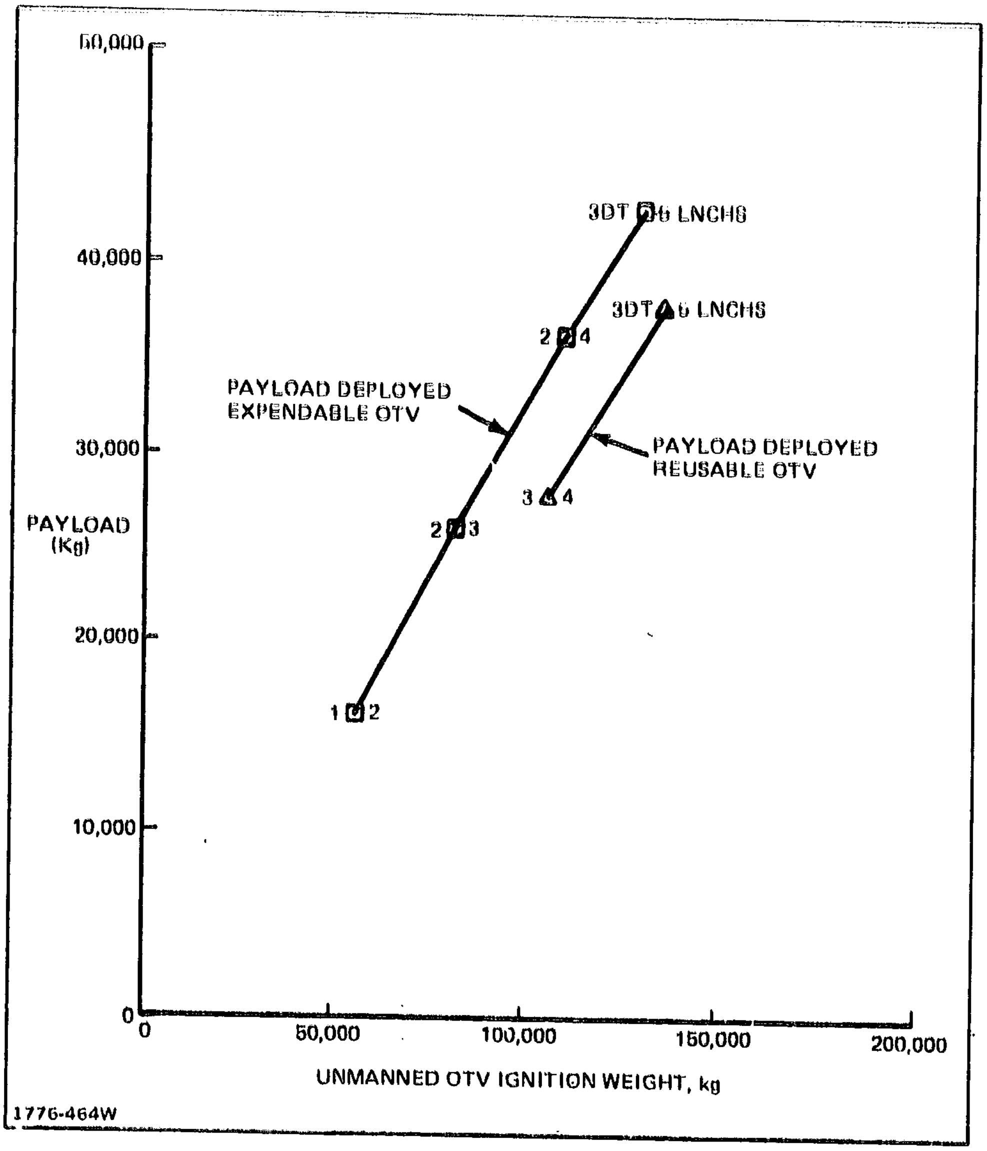

Fig. 6-20 Unmanned OTV Payload Capability for Ground Launched Payload

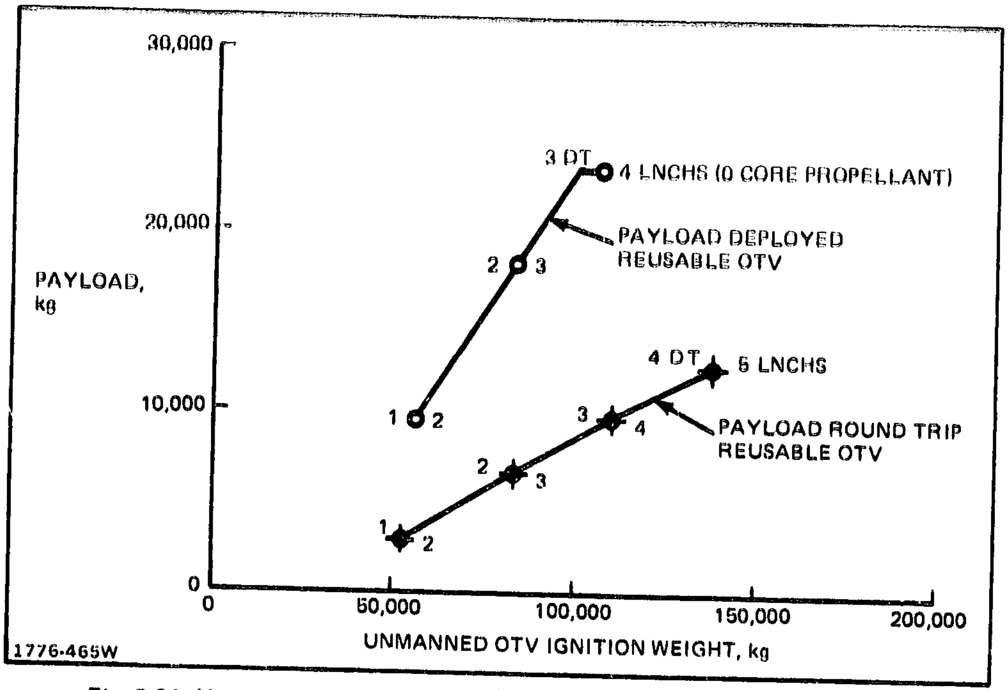

Fig. 6-21 Unmanned OTV Payload Capability for Ground Launched Payload

7 - CONCLUSIONS & RECOMMENDATIONS

The generic missions presented here represent a best estimate at this time of manned mission requirements for the future. As a design goal, the MOTV should endeavor to capture as many of these missions as possible within reasonable cost and funding constraints. The MOTV configuration selected to support these generic missions is a versatile, cost effective, design. It is capable of accomplishing nearly all generic missions with minimum modification. Propulsively, propellant drop tanks can be added to the propulsion core capability to handle the full range of payload requirements. Similarly, the crew module can be kit modified at low cost and weight panalty to accommodate a wide range of crew sizes, mission duration, and mission dedicated hardware. Future studies should continue to develop this type of versatile MOTV design.